THE

ELECTRIC TELEGRAPH

IN

BRITISH INDIA:

A Manual of Instructions

FOR THE

SUBORDINATE OFFICERS, ARTIFICERS, AND SIGNALLERS EMPLOYED IN THE DEPARTMENT.

BY

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PREFATORY NOTICE.

A brief sketch of the measures connected with the construction of the Electric Telegraph in India will form the most appropriate introduction to this "Manual of Instructions."

In April and May, 1839, the first long line of Telegraph ever constructed in any country was erected by the writer of these pages in the vicinity of Calcutta. The line was twenty-one miles in length, embracing 7,000 feet of river circuit. The experiments performed on this line removed all reasonable doubts regarding the practicability of working Electric Telegraphs through enormous distances, a question then, and for three years later, disputed by high authorities, and regarded generally with contemptuous scepticism.

It is never too late to acknowledge an obligation. In the experiments then carried on I received the warm aid and support of Dr. Wallich, then Superintendent of the Botanic Gardens of Calcutta, now Vice-President of the Royal Society of London.

One terminus of the line was placed in his house. All the resources of his establishment and library were held at my disposal. He saw at a glance the marvellous future

which these and simultaneous experiments in other countries foretold, and with his high name he protected the experimentalist from much of the derision which his attempts excited in the community of Calcutta.

The experiments having been completed, and their results published,* the line was taken down.

In 1850, a despatch from the Court of Directors to the Government of India re-called attention to the subject. The Government addressed the Military Board of Bengal, and reports were called for by the Board from Lieut.-Col. Forbes, of the Engineers, and from myself.

On these reports, dated December, 1850, being placed before Government, an experimental line of telegraph, half subterranean, half overground, thirty miles in length, was directed to be constructed.

This line was commenced in October, 1851, and opened to Diamond Harbour in December of that year. In the following May a branch was led to Moyapore. In August and December it was extended to Kedgeree, 80 miles distant by the line followed; and in March, 1852, the rivers Hooghly and Huldee were crossed, and the line from Calcutta to the sea opened for official and public correspondence.

These results having been duly reported, were under the consideration of the Supreme Government of India when hostilities commenced in Burmah. The services of the telegraph were thus brought into instant aud practical requisition, and its incomparable capabilities tested with complete success. The "Rattler," steam-frigate, bringing intelligence of the first operations of the war, had not passed

* *Journal of the Asiatic Society of Bengal*, September, 1839, p. 714.

the flagstaff of Kedgeree, on the 19th of April, when the news of the storming and capture of Rangoon was placed in the hands of the Governor-General in Calcutta, and posted on the gates of the Telegraph Office, for the information of the public.

On the 14th of April, 1852, Lord Dalhousie, as Governor of Bengal, laid before the Government of India a long and deeply-interesting Minute, in which his Lordship proposed the construction of lines from Calcutta to Agra, to Bombay, to Peshawur, and Madras; and the deputation of the author of this Manual to England, to give evidence before the Court of Directors, and assist in the dispatch to India of the requisite materials and stores.

I left India on the 3d of May, 1852 and reported my arrival at the India House on the 26th of June. On the same day I had the gratification to hear from the Chairman of the Court of Directors, Sir James Weir Hogg, that the Governor-General's propositions, which arrived *viâ* Marseilles on the 14th, had been already sanctioned by the Court of Directors, and approved of by the Board of Control, and that a despatch from the Court was already on its way to India in reply to the Governor-General's letter.

Such rapidity in the dispatch of an important measure is, perhaps, without a parallel in any department of Government. All subsequent steps were taken with proportionate speed. The requisite contracts were issued for all the stores, before the 1st of August. Sixty enlisted artificers were placed in training at Warley; an inspection of the home and foreign telegraph lines undertaken, and completed by the 15th of November; collections made of all the instruments in use in Europe and America; these pages

prepared for the guidance of the persons to be employed on the works in India; and voluminous reports, with estimates and drawings, submitted from time to time on every step of these proceedings.

The accompanying list of the materials and instruments ordered on the 1st of August, 1852, will show the enormous scale on which the operation was sanctioned, and the rapid rate in which the preparations have been made:—

	Tons weight.
Iron rod, No. 1 galvanised, 5-16th inch; weight per mile, ½ a ton; length, 5,600 miles	2,800
Iron screw piles, 46,000, each 76 lbs.	1,560
Gutta percha covered copper wire, 700 miles	
Iron wire, galvanised, No. 8, 500 miles	100
	Number
Oak brackets	48,000
Galvanised wrought iron caps	48,000
Binding screws for ditto	48,000
Stoneware insulators	96,000
Galvanised screws for ditto	96,000
Straining machines	20 sets of each.
Wire straightening ditto	
Gutta percha tool chests	
Sets of sundry tools	

Telegraphic instruments and samples of stores, &c., from all English offices; also from America, France, Baden, and Prussia.

Electric clocks, printing presses, turning lathes, wire drawing machines, and silk covering, taping, and ribboning machines; from Hopkinson and Cope, London; Whitworth and Co., Manchester; Holtzappfel, London; Shepherd and Son, London; Mr. Physick, of London, &c. &c.

Of all the above stores, and many others not included, there was not a single item manufactured or procurable on the 1st of August, 1852.

In all the stages of the requisite measures the utmost alacrity was evinced by every officer concerned. Having been much in personal communication with Mr. Juland

Danvers, of the Secretary's Office, I would desire to express my special obligations to him for the facilities which, on every occasion, he afforded me in the transaction of the business connected with that department of the India House.

To Mr. C. Manby, the Secretary of the Institute of the Civil Engineers, cordial thanks are due for valuable information regarding the best mode of obtaining supplies.

Mr. C. V. Walker, the eminent Superintendent of the South Eastern Telegraph line, with great kindness gave full opportunities for observing the English system in his offices; to Sir James Carmichael, and the Directors of the Submarine Company; to Mr. Statham, the Manager of the Gutta Percha Works; Mr. Wollaston and Mr. Crampton, the Engineers of the Submarine Lines to Calais and Ostend, I am also much indebted for the courtesy and readiness with which they facilitated every inquiry, and permitted experiments to be made on their lines.

To M. Alphonse Foy, the distinguished Director-General of the French lines; M. Breguet, of the Board of Longitude of Paris; Mr. Kelsch, of the Strasburgh Telegraph Office; the Baron Von Reisenstein, at Carlsruhe; M. Von Oppenheim, at Cologne; and M. Vinchent, at Brussels, are also due our warm acknowledgments.

I cannot close this list without a grateful tribute to the cordial kindness with which Colonel Hay, Colonel Leslie, and their brother officers at Warley, handed over to the telegraph service the sixty best men of the Depôt Battalion, and to the good-humoured forbearance with which they allowed the trim parade ground on Warley Common to be disfigured by our unsightly lines and irregular entrenchments.

The artificers are now on their voyage to the East, and in October next twenty camps of construction will be engaged in extending the web of telegraphs all over India. The duty is a noble one. If it presents many difficulties and some dangers these will but enhance the merit of the success which energy and zeal and attention will certainly accomplish. The history of the Telegraph in India must convince every one employed that, while unavoidable failures are looked upon with indulgence, successful exertion is certain of proportionate reward. Let us all, then, vie with each other in the execution of our exciting task, and indulge in the hope that we may be spared to witness the miracle of Calcutta and Bombay exchanging despatches in minutes instead of weeks—when the answer may arrive from one thousand miles before the ink is dry on the record of the question—and when persons more than that distance from each other can communicate more quickly than the inmates of different rooms in the same house.

In the extracts appended from the Governor-General's Minute I have ventured to omit the generous notice his Lordship has been pleased to take of my slight services. While I have done so from a very natural feeling, which his Lordship will be the first to recognise, I do not hesitate to say that that Minute imposes on me the honourable duty of devoting all the exertions of my life to the justification of the opinions the Governor-General has therein expressed.

I have only to add that, if in my notice of any English or foreign line or instrument, I have spoken in terms of slight commendation, it has simply been intended with reference to their inapplicability in India. I am not so proud

sumptuous as to obtrude opinions regarding the appropriateness of any system or contrivance in England. The eminent engineers in charge of the English lines are the best judges of what concerns their sphere of operations, as we may in India claim to be in most matters regarding our duties in that country.

W. B. O'S.

London, 14*th May*, 1853.

EXTRACTS FROM A MINUTE BY THE MOST NOBLE THE MARQUIS OF DALHOUSIE, GOVERNOR GENERAL OF INDIA, AND GOVERNOR OF BENGAL, DATED 14TH APRIL 1852.

1. Dr. W B. O'Shaughnessy has submitted his last report announcing the completion of the line of Electric Telegraph from Calcutta to Kedgeree. In all its parts, as well in that portion of the line which is carried underground as in that which is conducted after the European manner, its success has been complete. Neither the heat nor the rains, neither the violent atmospheric influences nor the thunder-storms and hurricanes to which it has been exposed during the past twelve months in a degree which will probably never be exceeded, have interrupted the full and continuous working of the line. Even the more difficult object of carrying the wire in safety across the Hooghly, where it is so liable to injury by the shipping, appears to have been fully accomplished. A mechanism and a system both admirable for their simplicity, and therefore doubly valuable in India, and under the circumstances in which the telegraph will be worked, have been devised and brought into operation.

An establishment of young lads has been trained, and have conducted the duties hitherto with regularity and to the satisfaction of the Government and of the public.

Financially the experiment may be regarded as quite successful. The monthly charge amounts to rupees 916, while the receipts from private parties exceed rupees 923, leaving the whole of the Government business conducted almost without charge. In like manner, it appears from Dr. O'Shaughnessy's letter, that the entire line, 80 miles in length, has been constructed for a sum lower than the estimate by 13,000 rupees.

2. I have visited the line, and in common with hundreds of others can bear testimony to the beautiful simplicity of the work, to the regularity of its operations, and to the perfect success of it as a national experiment of the highest and most immediate moment to the interests of India. In truth, the best of all testimony is borne to it by the periodical delivery every three hours during each day of intelligence from each station between Calcutta and Kedgeree up to the hour at which the intelligence is delivered here in Calcutta.

* * * * * *

5. The complete success of the experimental line has added intensity to the ardent desire I have entertained, ever since the first report on the subject was submitted, to see the main line of Electric Telegraph between Calcutta and Peshawur, Bombay and Calcutta, Madras and Calcutta, fairly commenced before I quit India next year.

6. The vast advantages of such a communication, if feasible, are apparent at a glance. The experimental line has shown not only that it is feasible, but that it may be

made easy of accomplishment, rapid in execution, cheap of construction, and profitable in its returns.

7. If additional proof of its political value were required, it would be found in recent events, where the existence of an electric telegraph would have gained for us days when even hours were precious, instead of being dependant for the conveyance of a material portion of our orders upon the poor pace of a dâk foot runner.

8. Since, then, the early establishment of the Electric Telegraph is all important alike to the Government and to the community in India—since it has been shown to be practical, safe, cheap, and profitable—I entreat the Government of India to second with all its authority my most urgent personal solicitation to the Honourable Court of Directors, that they will authorise the immediate construction of a line or lines from Calcutta to Agra, to Bombay, to Peshawur, and to Madras, either simultaneously or as soon as possible, in the order in which they are placed in my list.

9. Relying confidently on the acquiescence of the Government of India in this request, I would beg to offer some suggestions for expediting the submission of the question to the Court, and for giving effect to its consent, which I am satisfied will not be withheld as soon as the Court shall be convinced of the correctness of the results we are now about to lay before them.

10. Everything, all the world over, moves faster now-a-days than it used to do, except the transaction of Indian business. What with the number of functionaries, boards, references, correspondences, and several Governments in India, what with the distance, the reference for further information made from England, the fresh correspondences

arising from that reference, and the consultation of the several authorities in England, the progress of any great public measure, even when all are equally disposed to promote it, is often discouragingly slow.

11. In the present instance the inconveniences usually felt in this country have been obviated by causing Dr. O'Shaughnessy to communicate direct with the Government of Bengal. His report of the completion of the line has thus been considered by the local Government without delay, and I trust it will be speedily forwarded to the Court by the Government of India. I am very desirous to expedite and facilitate its consideration by the authorities in England.

12. To that end I beg leave respectfully to recommend to the Governor-General in Council, that Dr. O'Shaughnessy should be directed to proceed to England at once, simultaneously with the transmission of the Report.

His presence will enable him to give every information to the Honourable Court respecting the system he has established and its operation. His accounts will enable the Court to test the estimates for the extension of these lines by examination of past expenditures. All necessity for reference to India will be removed, and the Court will be in a condition to pronounce its decision at once.

* * * * * *

13. I have already stated that I cannot doubt that the decision of the Court will sanction this work. In that case Dr. O'Shaughnessy's presence in England will be of great additional value; with the sanction and under the direction of the Court, he will be able to direct the preparation of materials for the Electric line on very favourable terms.

and with that speed and in those quantities which alone will lead to a speedy establishment of the whole line. This could not be effected in India.

14. As I cannot doubt that, if this line be carried on, the past services of Dr. O'Shaughnessy will entitle him in the eyes of the Government to be selected for the superintendence of the larger work, his visit to England will be further valuable by giving him the opportunity of becoming acquainted with the English, the continental, and even the American systems and modes of construction.

* * * * * *

Heartily commending this matter to the favourable consideration of the Governor-General in Council, I trust it will meet with an early assent.

DALHOUSIE.

(Signed) J. W. DALRYMPLE,

Under Secretary to the Government of Bengal.

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*** We have accidentally omitted to state in the proper place that the instruments used in the Bengal offices are very accurately made, in sets, by Mr. Charles Shepherd, 53, Leadenhall-street, London; price, alarm included, £5. Mr. Shepherd also manufactures electric clocks, several of which have been purchased for the Indian lines.

THE

ELECTRIC TELEGRAPH

IN

BRITISH INDIA.

The following pages are intended to afford full and precise practical instructions for the construction of the lines of electric telegraph in British India—the use of the instruments to be employed — the arrangements of offices for correspondence — the protection of lines and offices from lightning, and the measures of precaution to be adopted during the violent gales by which India is frequently visited.

The principles of electricity and magnetism are explained to the full extent required for the instruction of the persons employed in erecting the lines, and in arranging and carrying on the telegraphic correspondence.

The properties of all the materials used are carefully described, and in many cases their ordinary native names and market prices are specified, with reference to the Bengal lines.

The text of each page is restricted to the directions and information appertaining strictly to the construction and working of the Indian lines, as sanctioned by Government, after deliberate consideration. But ample notes are appended in a smaller type, or given under separate heads, which afford full information on the methods adopted on other lines, whenever such knowledge may illustrate any point of interest in the Indian system.

It seems desirable to add, that these practical directions are printed solely for use in India. Further, the brief exposition

of the principles of electricity and magnetism with which the instructions open, is given for the information of artificers, signal pupils, and other imperfectly educated persons, and is not intended for the higher class of officers who may be employed in the department.

ELECTRICITY.

To understand how to construct lines of electric telegraph, and to correspond by means of this invention, it is necessary to know the nature and sources of electricity, the properties of magnetic bodies, and of those substances employed in the construction of the lines, and of the instruments used in correspondence.

The term *Electricity* is employed to denote a peculiar state into which several substances are brought by various causes—the state differing from their ordinary condition, and made manifest by the occurrence of sparks, of shocks to living animals, of attraction or repulsion of moveable substances, by chemical changes and magnetic action.

The electric state is readily illustrated by the following examples:—

A cloud, when electric, darts flashes of lightning to all bodies which it approaches.

A glass plate, when rubbed by silk, emits electric sparks in the same manner.

Sealing wax, sulphur, resin, amber, lac, gutta-percha, are capable by mere friction of exhibiting similar phenomena.

If a steam boiler be placed on glass legs, and a jet of steam be blown off at a high pressure through a wooden orifice, the boiler becomes powerfully electric, and gives off vivid sparks to metals and living animals brought into its vicinity.

There are many animals, such as the torpedo and electric eel, which by their voluntary act can assume this condition, giving sparks and shocks to other objects.

In very dry countries most animals, but especially cats, can be made electric by rubbing or combing their hair or fur.

Chemical action is a common and important source of electri-

city; thus, a zinc rod or plate, placed in dilute sulphuric acid, is acted upon chemically, sulphate of zinc being formed. If a plate of copper, silver, platinum, or gold be placed in the liquid at the same time with the zinc, it is easy to obtain the spark, shock, and other phenomena of electric excitement.

Electric action can also be caused by magnets, as will be subsequently explained, and by exposing arrangements of certain metals to the influence of different temperatures; lastly, the vicinity of a substance in electric excitement is sufficient to cause electric activity in others, a fact which is termed *induction*, and which has an important influence on many telegraphic arrangements.

Such being the general nature of electrical excitement and its sources, a closer study must be made of the facts which bear on the construction and use of the electric telegraph.

Electric action exhibits two varieties, to which the terms *positive* and *negative* are respectively applied. That caused by the friction of glass is positive; of resin, lac, gutta-percha, sulphur, negative; a plate of zinc, and another of gold, silver, copper, or platinum, in dilute acid, are—the zinc negative, the silver, &c., positive.

The states are distinguished by positive bodies attracting those which are negative, and repelling those in the same state as themselves—and by certain chemical and magnetic effects, which will soon demand our careful consideration.

Electricity further exhibits effects of two distinct kinds, when in motion and when stationary—the former is termed the *dynamic*, the latter the *static* state. It is with *dynamic* electricity chiefly that the telegraph is concerned.

The metals, water, wet earth, and all wet substances, are found to conduct electricity from one place or body to another; resins, glass, sulphur, gutta-percha, caoutchouc, silk, shell-lac, &c., either do not conduct electricity in any sensible degree, or do so to a very slight extent. For that form of electricity caused by the action of liquids upon metals, dry air, wood, paper, or, indeed, all dry substances, not metals, metallic compounds, or carbons, are *non-conductors;* while, on the contrary, metals act as conductors. The former are also termed *insulators*,

as they insulate or confine the electric excitement to the body through which it passes.

Before proceeding to describe the construction of the voltaic pile or battery, it is necessary to explain the nature of magnets, which in various forms are used as simple and easily applicable tests of the presence of dynamic electricity, electricity in movement, or the *electric current.*

MAGNETS.

There are some ores, or natural compounds of iron, which when hung up by a thread, so as to move freely, always settle in a determinate position towards the north and south poles of the earth.

If a steel needle be placed in a line drawn between the north and south poles of the earth, which is termed the *magnetic meridian*, and at a particular angle or *dip*, it soon acquires magnetic properties, and if balanced on a pivot, will point north and south; and if disturbed from this position, will return to it after a series of oscillations. The ends are termed north and south poles.

When two magnetized needles are brought near each other, it is observed that similar poles repel, dissimilar poles attract each other. The north pole of A repels the north pole of B, and the north pole of A attracts the south pole of B.

The earth is itself a great magnet. The earth has magnetic poles, and it is by the power of these poles that the needle is forced to assume its determinate position.

A delicate pocket compass needle, of one to two inches long, finely balanced, is a valuable instrument in studying the laws of electricity and magnetism on which the telegraph depends.

VOLTAIC OR GALVANIC ELECTRICITY.

The source of electricity of most importance to the telegraph student is that exerted by chemical action on metals. It is termed *Voltaic* or *Galvanic*, from Volta and Galvani, two illustrious Italian philosophers, to whom its discovery and first investigation are due.

If two plates of different metals (zinc and copper) be placed in a liquid which can act chemically, on one and not on the other (such as salt water, or water acidulated with sulphuric acid), and if the plates be joined by a metallic wire, electricity may be detected moving or flowing as a current in the wire, W, and from one plate to the other, through the fluid (*Fig.* 1). If the wire

Fig. 1.

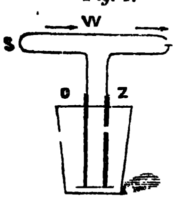
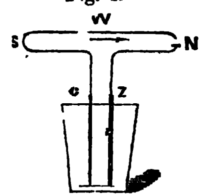


Fig. 2.



be divided at N, so that the ends can be separated or joined at pleasure, it is readily proved that the electric current ceases to move when the wires are separated from each other. While the action proceeds, the zinc is charged with *negative*, the copper with *positive* electricity. The current moves from the zinc to the copper in the fluid, and from the copper by the intermediate wire to the zinc. Thus the wire attached to the copper is positive, to the zinc is negative, in its effects.

Fig. 3.

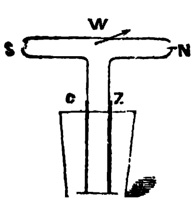
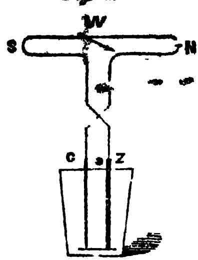


Fig. 4.



The test employed is the magnetic needle. Arrange the plates and wire so that the wire points north and south. Separate the ends of the wire, and place the needle immediately below it. The needle remains at rest (*Fig.* 2). Let the wires touch

the needle instantly moves, and tends to place itself east and west (*Fig.* 3). It is further seen that if the ends of the wires be changed from one plate to the other, so that that which first touched the zinc now touches the copper, the needle is deflected in the opposite direction to that in the former arrangement (*Fig.* 4).

The deflection is caused by the electric current in the wire. The wire is thereby rendered magnetic; but its north and south forces are not at its ends, as in the steel magnet, but distributed equally round its circumference, so that any two opposite points on this have opposite magnetic powers; and on changing the order of contact in the wires, the magnetic force in the wire is also reversed, north becomes south, and south north.

This is proved by placing the testing needle in different positions regarding the wife—above, below, to the right, to the left. Observe and note the order of the deviations. If the conducting wire be covered with silk and wound round a frame forming several turns, and the compass-needle be placed in the centre, all the forces combine in their effects on the needle in direct proportion to the number of turns. This arrangement is termed a *multiplier* or *galvanometer*. It is essentially the telegraph used on the Indian lines, and is employed on the French lines (*Boussole de Sinus*) to measure the intensity of the electric currents circulating in the conductors. A minute description of this instrument is now required.

THE SINE MULTIPLIER.

A, B, C, is a graduated circle placed on the circumference of a circular frame of wood, A, C. In this frame is a circular piece of wood, *a*, *b*, *c*, which can turn horizontally about its centre, A, B, C, remaining fixed. An index, *i*, placed on the circumference of the moveable piece, serves to measure its rotation on the divisions of A, B, C. D, E, is an open frame of wood, placed perpendicularly to the surface of the moveable piece, and surrounded by several turns of copper wire covered with silk. In the centre of this frame is a very sharp point of hardened steel, serving as a pivot for the magnetic needle, *x*, *y* (*Fig.* 6). A needle of thin brass, *z*, *t*, is placed at right angles across

the centre of the steel needle, the cross-shaped compound needle being supported on a cap of agate, balanced exactly on the steel

Fig. 5.

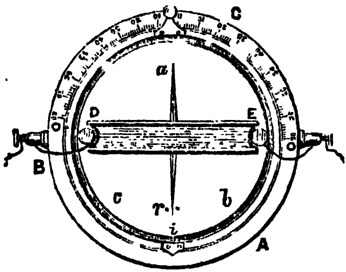
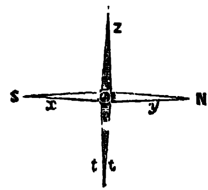
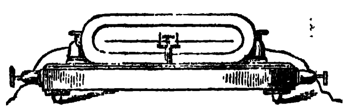


Fig. 6.



pivot; *r* (*Fig.* 5) is a guide or stop to limit the vibrations of the needle. Thus the central piece of wood, the open frame, the needles, and the stop, *r*, form a moveable system round the centre. The whole is arranged so that the frame of wire lies north and south, or in the magnetic meridian. The steel needle resting in that direction within the frame, the points of the brass needle will be respectively east and west, and one of its ends midway between the sides of the stops, *r*. *Fig.* 7 shows a side view of the instrument.

Fig. 7.



If an electric current be now made to circulate through the wire surrounding the frame, the needle will turn on its pivot, and the extent of its deviation will depend on the energy of the current, although not in a direct proportional degree—that is, suppose from two different sources we obtain successively two currents, one marking 10 deg. and the second 20 deg., we still cannot conclude the second current to have double the power of the first.

To obtain the exact proportional measure of two currents, the instrument is set—one current is passed, and the circle, *a*, *b*, *c*, is turned in the same direction as the deviation till the brass point of *z t* rests in the centre between the stops. The division of the graduated circle to which the index, *i*, now points gives the angle which the needle in its actual position makes with the magnetic meridian. This is noted. Suppose it 30 deg. in a given case. The second current is passed—suppose the angle to be 45 deg. The ratio of the intensities of the two currents is that of the two numbers, expressed mathematically as the *sines*, the values of which are found in tables constructed for the purpose. In these tables it is found that the sine of 30 deg. is = 0·50, and that of 45 deg. is = 0·70, the ratio is accordingly as 5 to 7.

If the deviation be so great that the needle is forced beyond the limit of the centre of the stops, recourse must be had to frames or coils of wire of different dimensions, as will be subsequently pointed out.

For testing the strength of the current to be used on a line, this multiplier is constructed with fifty yards of copper wire, covered with silk, and $\frac{1}{30}$th of an inch in diameter. For use as a *telegraph*, the coil in the Indian instruments is of thirty feet of silk-covered copper wire only $\frac{1}{130}$th of an inch in diameter.

Great obscurity exists in the descriptions given of the deviations of the needle by voltaic conductors, chiefly from neglecting to specify the exact relative positions of the plates in the battery, the turns of the wire, and the face of the observer. Theoretical expressions are also too often made use of, such as ascending and descending, positive and negative currents, &c. In the following description the facts are minutely stated.

The battery is arranged in the magnetic meridian with its copper end to the south and its zinc end to the north. The observer is seated with his face to the west, the zinc end of the battery being opposite to his right hand, and the copper end opposite to his left. The wire from the copper end of the battery is wound on a frame from left to right, in the same direction as the motion of the hands of a watch, and a magnetic needle is inclosed in the frame in such a manner that the wire turns round

it from left to right. On making contact with the battery, the north pole of the needle deviates to the west. On reversing the poles of the battery, the north pole of the needle deviates to the east.

The above description also applies precisely to the facts observed when the magnetic needle is placed *below* a single wire, joining the poles of the battery, when battery and observer are situated as above described.

The exact structure and experimental use of this instrument are of such great importance, that the teacher is recommended to pause here, and proceed no further till this be thoroughly learned.

THE VOLTAIC BATTERY.

All the voltaic batteries used for telegraph purposes consist of one or more couples, of which zinc is one, the second being copper, silver, platinum, or carbon, in various arrangements.

Each couple is termed an *element;* a series of such couples a *battery*.

The liquid which acts on the zinc is generally water acidulated with sulphuric acid, or containing common salt in solution.

Common zinc contains many impurities, and is irregularly acted upon by acid; but if the zinc be moistened with weak acid, and then rubbed with mercury, an *amalgam* is formed, which is scarcely acted upon by dilute sulphuric acid, except the plates be connected by a wire, forming a circuit. This amalgamated zinc is a most important substance in telegraph arrangements.

In every zinc battery in use the chemical action is accompanied by the decomposition of water into its two gaseous elements, hydrogen and oxygen.

The oxygen unites with a portion of the zinc, forming oxide of zinc, the latter with the acid forming a salt of zinc. The hydrogen either escapes on the surface of the copper, silver, platinum, or carbon plate, or in certain and very powerful arrangements it is absorbed by nitric acid, oxide of copper, or chloride of silver, as shall be subsequently explained. The removal of the hydrogen from the surface of the copper, silver, or platinum pole,

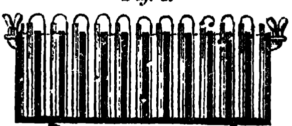
increases the power of the battery in an extraordinary degree, owing, it is supposed, to hydrogen being a gas of very great insulating power.

The following kinds of batteries are those used on the telegraph lines now in practical operation :—

Sand and Acid.

A plate of cast zinc (*Fig.* 9, *z*), four inches square, and $\frac{3}{16}$ths of an inch thick, is joined by a copper strap, one inch broad, to a thin copper plate (*Fig.* 9, *c*), four inches square. The zinc is well amalgamated with mercury.

Fig. 8.



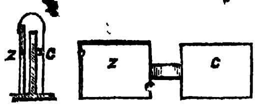


Fig. 9.

Twelve of these couples are arranged in a trough of wood, porcelain, or gutta-percha, and divided by partitions into twelve water-tight cells, each $1\frac{1}{4}$ inches wide. The zinc and copper preserve the same order and direction throughout. When arranged, the trough is filled with the finest white sand, and then moistened with water, previously mixed with 5 per 100, by measure, of pure sulphuric acid (*Fig.* 8).

The gutta-percha troughs made by Mr. Statham are fitted with close covers.

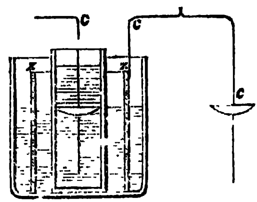
Batteries thus prepared remain in constant, though weak, action for several weeks, or even months. They are used almost exclusively on the English lines, and answer well for working *needle* telegraphs in fine and dry weather. In fogs and rains, at distances exceeding 200 miles at most, their action ceases to be sufficient for certain work, and a vast number of couples must be employed, 144 to 288 being frequently in use. For working instruments such as those used in France, Prussia, and America, sand batteries fail altogether, and in India they have been discarded, after full trial, as in all respects inferior to other batteries subsequently described.

Daniel's Battery.

This battery is named after its inventor, the late distinguished professor of natural philosophy in King's College, London.

Each element consisrs of a st-ap of copper, carrying a little circular shelf of the same metal (*Fig.* 10, *c*), one inch wide, and six inches long—a porous cup or cylinuer of unglazed earthenware, two inches in diameter, and six inches deep—a cylinder of sheet zinc, with a thin copper strap to join it to the next couple. The zinc is not amalgamated. A glass tumbler holds the entire, thus:—

Fig. 10.



From 2 to 100 of these elements may be arranged in series, and are thus set in operation. The vessels are filled with common water to within half an inch of the edge, and about one ounce of crystals of *sulphate of copper* (blue vitriol) placed on the little circular shelf. The cell is now ready. The addition of a little common salt to the water in contact with the zinc increases the power of the arrangement.

To keep this battery in efficient action, a little sulphate of copper must be added as the solution grows pale, so as to keep it of a blue colour. Once a week, at least, all the solutions should be changed and the plates washed.

Sulphate of copper is made in all parts of India, and sold retail at 20 rupees (£2) for 80 pounds avoirdupois. The usual native name is *neel tutya.*

A modification of the battery thus described consists in placing a *rod* of *cast* zinc in the centre, and a cylinder of copper outside the porous earthen cylinders. This arrangement is often useful where *sheet* zinc is not procurable. Every bazaar in India supplies common zinc (*das*. *t*), sheet copper (*tamba*), mercury (*para*), and copper wire, so that a battery of this kind can always be constructed when required. This is the more important as the mineral acids, sulphuric and nitric acids, are only made at the capitals, Bombay and Calcutta; and the danger and difficulty

of their carriage render their cost at inland stations a serious obstacle to their general use.

In arranging a series, say of 20 couples, of this battery, it is of the utmost importance that the glasses be kept dry outside, and no liquid be spilled about the table or frame on which they stand.

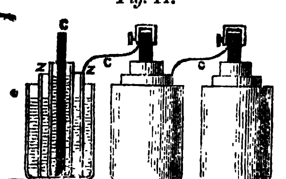
When this battery has been some time in activity, new copper is observed to deposit itself on the copper plates, from which, from time to time, it may be stripped off, and reserved for future conversion into new sulphate of copper, or sale to the makers of that article.

These sulphate of copper batteries are extensively used on the French and German lines. 60 couples suffice in France for the longest lines yet open; viz., from Paris to Bordeaux, 284 miles; Paris to Strasburgh, 312½ miles; Paris to Brussells, 231¼ miles; the signals not being repeated on the way.

Carbon Batteries—Bunsen's.

In these a cylinder of prepared carbon, open at both ends, is substituted for the copper. This carbon cylinder is placed in a glass or porcelain vessel of about a pint measure. Inside the carbon is a porous earthenware cylinder, closed at the bottom. In this is placed a rod of amalgamated zinc. Nitric acid mixed with its own bulk of water is poured into the vessel in contact with the carbon. A mixture of sulphuric acid 1 part, water 25 parts, by measure, is poured into the porous cup in contact with the zinc.

Fig. 11.



Contact is made by a strap of copper securely fixed all round the top of the carbon cylinder, protected by a resinous cement from the acid, and provided with a brass binding screw to receive a wire from the next zinc element.

This arrangement may be varied by using a solid cylinder of carbon in the porous earthen vessel in the centre, and a zinc cylinder outside next the glass (*Fig.* 11).

This is the method followed in the central office in Paris. One battery of 40 such couples suffices for working all the lines from Paris, at the same moment. The batteries are cleaned and fresh acid given every week. The arrangement is one of great power.

In Prussia, carbon batteries are also much used, but no nitric acid is employed; weak sulphuric acid (1 of acid to 20 of water, by measure) is placed in contact with the zinc, which is well amalgamated, and acid of 1 part sulphuric acid to 9 parts water is used in contact with the carbon plate.

Nitric Acid and Platinum.

The batteries to be described under this head are those used at present in the several telegraph offices on the lines between Calcutta, Diamond Harbour, and Kedgeree.

Each element consists of a cylinder of sheet zinc, three inches deep, provided with a copper connecting wire; a porous earthenware cell, and a piece of platinum wire, six inches long, of which three inches are coiled into an open spiral, half an inch in diameter. The whole is placed in a half-pint glass tumbler.

The element is charged by placing salt water in contact with the zinc, which is not amalgamated, and dilute nitric acid (equal measures of strong nitric acid and water) in the porous vessel, and into this the platinum spiral dips, the other end being wound round the wire from the zinc of the *next* cell. Two of these cells suffice to work a line of forty miles, totally uninsulated, and including the submarine crossing of the Hooghly River, 6,200 feet wide.

The liquids require renewal every fourth day.

The platinum wire has many advantages over platinum foil, which is used in America. The foil soon becomes brittle and torn. It is much more expensive. The contacts are made and maintained with much more difficulty. The liquids are also changed, and the whole apparatus mounted and taken to pieces with much greater facility when wire is employed.

Each porous cell contains four fluid ounces of liquid. These cells are made of ordinary brick clay, and are supplied by the native potters at the rate of 64 for 1 rupee, or 2s.

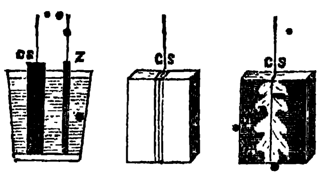
In America, 30 platinum couples are used for every 100 miles of line.*

Fused Chloride of Silver.

This battery, invented by the author, and not hitherto described, is, for many purposes connected with the telegraph, deserving of attention in this place.

The mode of preparation of the fused *chloride of silver* is described in the Appendix.

Fig. 12.



a *b* *c*

Each plate of fused chloride of silver is two inches square, and half an inch thick. A silver wire is twisted round it thrice, as shown in *Fig.* 12, *b*, and firmly fastened, so as to leave an end of about three inches long. A plate of this substance is associated with a plate of cast zinc of equal size, not amalgamated, and the whole placed in a glass of weak salt water (*Fig.* 12, *a*). Series of these couples may be associated together in the ordinary way.

This arrangement may remain for years without any local action taking place, until the wires are united by a conductor. When the circuit is closed, a current passes; water is decomposed, the hydrogen acting on the chloride of silver, unites with chlorine, and liberates metallic silver, and forms hydrochloric (muriatic) acid, by which the oxide of zinc is dissolved.

The metallic silver is reduced in a fern-like shape, com-

* Jones's Historical Sketch of the Electric Telegraph in the United States, New York, 1852. Vide p. 96.

mencing at the silver wire, and extending in all directions (*Fig.* 12, *c*). Eventually the chloride is all reduced to the metallic state. It is then inefficient, and should be broken up, well washed with rain water to free it from salts of zinc, and melted into an ingot for reconversion into chloride.

The advantages of this battery are its absolute constancy and uniformity of action—the total absence of local action—and the great length of time during which it remains ready for work, provided the evaporation of the liquid be prevented. The chloride of silver is costly, 25 per 100 less than pure silver; but as all the silver is recovered, it is only the cost of the nitric acid used in preparing it, which is to be taken into account.

In signalling power this battery is equal to the platinum and carbon arrangements, but its chief value is for local circuits, in which its use will be subsequently pointed out.

Stöherer's Charcoal Battery.

Stöherer has made a very constant battery with zinc and charcoal. The zinc is not amalgamated. A solution of alum is the fluid used.

A wide jar of hard earthenware contains the pieces of charcoal, each of which is wound round with a copper wire.

In the middle of the jar is placed an earthenware cell. All the intervals are filled with garden sand. A piece of zinc, sheet or solid, is placed in the earthenware cell, which is then filled with sand. The whole is watered, from a flower-pot, with a solution of alum.

Schellen says he has seen a nine-element battery of this kind which had been used for telegraphic purposes for two years, and was nearly as strong as when first made.*

Before we can understand the applications and uses of these batteries, we must study the laws which affect the intensity of electric currents in different conductors. These laws have been most successfully investigated by Ohm and Wheatstone, and the following exposition is based upon that given by M. Bergon, in the French official instructions published in 1851.

* Der Electro-magnetische Telegraph, &c., p. 271, von Dr. H. Schellen. Brunswick, 1850.

LAWS OF THE INTENSITY OF CURRENTS.

A current cannot exist without an electric source and a conductor. Its intensity depends on the nature and the dimensions of the materials of the electric source and of the conductor, which must accordingly be separately considered.

Let us first take a constant battery and a varying conductor, then a constant conductor and a varying battery. The deflections of the magnetic needle in the sine galvanometer afford the following laws:—

Laws of the Conductor.

1. The battery being constant, the intensity of the current is the same in every point of the conductors it passes through, however the composition of these may vary.

2. For circuits of the same nature and section the intensity is in the inverse ratio of the length.

3. For circuits of the same nature and length the intensity is in the direct ratio of the sections.

4. All else being equal, the intensity varies with the nature of the conductor.

The laws relative to the nature and dimensions of the materials of the conductor are also applicable to the nature and dimensions of the materials of the battery; but the intensity of the current increases or diminishes with the energy of the chemical action in the battery. M. Bergon affords apt illustrations of these laws—thus:

1. Take a certain length (say ten feet) of iron wire, and an equal length of copper wire, and pass a current through this wire. Whatever point of this circuit we test by the magnetic needle, the deviation will be always the same.

2. Take two copper wires of equal thickness, one of 10 yards, one of 100 yards long. Pass successively through these wires the current of a constant battery. The intensity is not exactly ten times stronger than in the first case, and the law seems to be defective. But when we take into account the battery itself and

the wire of the *sine multiplier*, it will be found that the lengths of the two circuits are not respectively as 10 to 100, but as $10 + 3^* = 13$ to $100 + 3 = 103$. Let us now take two other wires, of the same thickness as the first, but one of 5, the second 50 yards long, and use the currents from the same battery and with the same *multiplier*. The intensities will be as $5 + 3 = 8$ to $50 + 3 = 53$—that is, the battery and multiplier are as 3 to be added to each number; and, this correction being made, the law is found to be exact.

3. Take two copper wires, one 10 yards long and $\frac{1}{30}$th of an inch in diameter; the second 10 yards long, and $\frac{1}{15}$th of an inch in diameter. Pass the currents of the same battery, and use the same multiplier, and, correcting for this as before, we find the deflection shows a current four times greater in the second wire than in the first.

4. Take a copper wire $\frac{1}{15}$th of an inch in diameter and 12 yards long; pass the current, and the sine multiplier will give say a deviation of 20 degrees. If we wish to procure the same deviation, substituting an iron wire of the same diameter for the copper, the length of the iron wire must be reduced to 2 yards. A certain length of iron wire produces, then, or the multiplier the same effect as six times its length of copper wire of the same diameter. The same deviation would have been obtained by having the same lengths, but the iron wire of six times greater section than the copper. The conducting power of copper is accordingly concluded to be six times greater than that of iron.

Conducting Power.

A conductor is said to be superior to another when, with equal diameters and lengths, it gives a more intense current from the same source.

Metals are the best conductors, but vary in their range from silver, which may be rated at 5,152, to gold, 3,975; copper, 3,842; platinum, 855; iron, 700; mercury, 100.

* 3 = value of the battery and multiplier-wire.

The temperature of the metal affects its conducting power. Between 32 deg. and 212 deg. Fahr. that of iron diminishes one-half. Charcoal in several forms is a good conductor. Acid and saline liquids also conduct well, and solutions of metallic salts, but the conducting power is infinitely weaker than in metals. Thus, solution of sulphate of copper is 2,500,000 times a worse conductor than platinum wire.

Resistance.

While conducting power depends on the nature of the conductor, resistance depends on the dimensions and nature of the whole circuit.

Thus, take two circuits, one a copper wire $\frac{1}{20}$th of an inch in diameter, and 10 yards long; the second an iron wire of the same dimensions—applying a constant battery to each successively, the current will be found to be six times stronger in the copper than in the iron circuit, and the iron is said accordingly to have six times the *resistance* of the copper.

Or, take two circuits, composed, one of 100 yards of copper wire, $\frac{1}{16}$th of an inch section. The second, an iron wire, 10 yards long, and $\frac{1}{8}$th inch section. The iron circuit being ten times shorter, and of twice as great section, although copper is six times a better conductor, still the resistance would be fourteen times greater in the copper than the iron circuit.

Laws of Complex Circuits.

In these the intensity of the current varies in the inverse ratio to the sum of the resistances of each part, or, in other words, the resistance of a complex circuit is equal to the sum of the separate resistances. Thus: Copper being six times less resisting than iron of the same diameter and length, the resistance of 1 yard of copper wire will be represented as 1; that of one yard of iron as 6, and soldered, end to end, the compound wire will have the resistance of 7, and will produce the same effect on the battery current as 7 yards of copper wire of the same section.

Resistance Coils.

Guided by the laws above explained, we can readily understand the use of "*resistance coils*" for *proving* telegraphic instruments and other experimental researches. These coils consist of very fine copper wire, generally $\frac{1}{128}$th of an inch in diameter, coated with silk, and wound in a bobbin, the length being from 500 to 5,000 yards in one continuous coil. Each end is attached by solder to a brass connecting screw.

A constant current being passed through such a coil, and its effect noted on the instrument under trial, we are enabled thereby to know through what length of iron line of known diameter the same battery power will work the instrument.

Suppose 5,000 yards of resistance coil are used, the resistance in this is equal to that of 1,000 yards of iron wire of the same diameter, or $\frac{1}{128}$th of an inch, because copper is superior in conducting power to iron as 6 to 1.

But as an iron rod of $\frac{5}{16}$ths inch section contains metal equal to 1,600 times that of the one of $\frac{1}{128}$th; and as the conducting power increases directly as the mass, the $\frac{5}{16}$ths iron rod is 1,600 times superior in conducting power to the wire under experiment reduced to a value of 1,000 yards. The resistance coil of copper wire of 6,000 yards of $\frac{1}{128}$th inch is therefore equal to a telegraph line of 1,000 yards iron wire $\frac{1}{128}$th inch, or of $1{,}000 \times 1{,}600 = 1{,}600{,}000$ yards of $\frac{5}{16}$th rod, or 909 miles and 160 yards of the Indian telegraph line.

The inference regarding this length is, however, liable to modification in actual practice through the telegraph line being exposed to the effects of rain, fogs, changes of temperature, and other causes producing loss of the electric current, or increasing the specific resistance of the line. But the resistance coils are still extremely useful, as an instrument under trial, which cannot be worked through a coil of great length, must fail altogether on a proportionate extent of telegraphic line.

Intensity of the Battery.

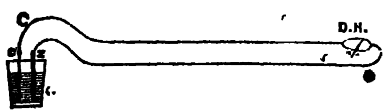
The intensity of a current may be increased by increasing the number of the elements of the battery, and by increasing the

chemical activity of the battery by the use of stronger acids. The increase of intensity caused by the addition of elements is most remarkable on very long lines. On short lines of slight resistance the effect is scarcely perceptible.

The Earth a Conductor, and used as a part of all Telegraph Circuits.

The earth has been described as a conductor of electricity, and in all telegraphic lines it forms a part of the circuit. To understand this clearly, let us suppose a battery circuit of a continuous wire extending from Calcutta, C., to Diamond Harbour, D. H., and the wire returning from D. H. to C., a sine galvano meter being interposed at D. H., and a constant battery at C. Distance thirty miles.

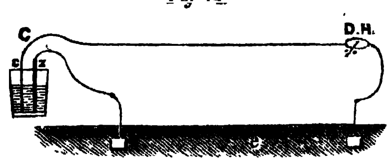
Fig. 13.



The current from *c z* produces a deviation of the needle at D. H. to a certain amount, say 15°.

Now cut away the whole of the second wire except a few feet at each end, which are connected by plates of copper with the damp earth thus—

Fig 14.



The current not only passes as before, but actually has increased in intensity, and the deviation will be found to be 30°, double its previous amount.

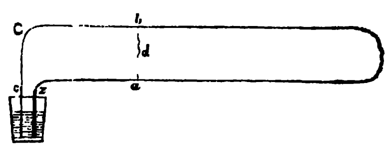
Thus the earth has apparently not only acted as a conductor, but has actually given no resistance to the current.

It is attempted to explain this by stating that the great mass of the earth renders it a conductor of less resistance than any metallic wire. But many experiments have failed in detecting any evidence of a current in the earth between the two buried plates. Many suppose that the earth absorbs the electricity conducted to it by the wire, and, acting as a common reservoir, conducts it no further. However it be explained, the fact is one of the greatest importance. It was discovered simultaneously by Steinheils, of Munich, and by the author of these pages. The experiments by the author were published in the Journal of the Asiatic Society of Bengal, in 1839, and extracts from the article are given in the appendix to this manual.

Derived Currents.

If in a current, C, *a, c, b,* you take two points, *a b,* and join these by a conducting wire, *a c b* will be the *derived wire*, and *a d b* the *derivation,* thus—

Fig. 15.

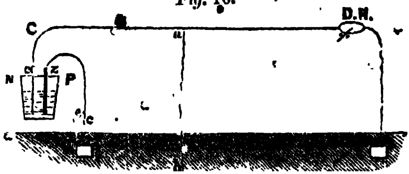


If the current is completed by the earth, as in the case of the Calcutta and Diamond Harbour line, and a derivation takes place at *a* to the earth, *E*, as the earth presents no resistance, the case will be the same as if there were direct metallic contact between the point of derivation, *a*, and the battery at *c* (*Fig.* 16).

Wherever insulation is defective on a telegraphic line, there is, during wet weather, a point of derivation to the earth; and this takes place chiefly at the posts on which the wires are supported. Where these points of derivation are numerous, by shortening the total circuit they cause the intensity in the battery and underived

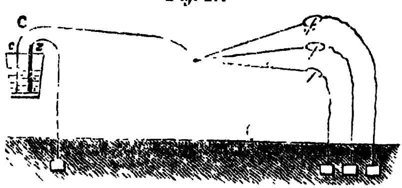
portion of the line to increase. This becomes a serious evil when the currents of each station are made to pass through its own instruments, as is the objectionable practice on all the English lines.

Fig. 16.



In considering the influence of derivation, it is, however, to be remembered, that the electric current, whenever it has a choice of paths, distributes itself through all, passing through each in the inverse proportion to the resistance it offers. The larger the conducting wire, the more of the electric it carries, and the smaller in proportion will be the loss by derivation. Again, if the current have two or more equal metallic paths to traverse, it will divide itself equally between all.

Fig. 17.



The influence of the earth in absorbing or conducting telegraphic currents seems to be directly in proportion to the moisture it contains. A river between two stations is accordingly found to afford far better communication than mere contact with the earth, or even immersion in a well. This has been repeatedly proved by experiments made on the line between Calcutta and Diamond Harbour, in which stations the offices are close to the Hooghly river. Shifting the wire from the river to a well by its side, is sufficient to diminish the strength of the signals in a very remarkable degree.

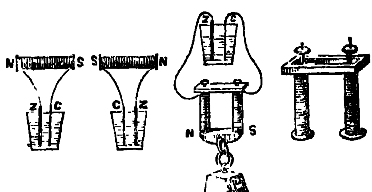
Magnetisation by Currents—The Electro-magnet.

Steel differs from iron in containing a definite proportion of carbon. Ordinary, or soft iron, is readily rendered magnetic by contact with a magnetic body, but loses its magnetism as soon as the contact is broken. Steel is more slowly and difficultly rendered magnetic, but it retains permanently the magnetism it has received.

Electric currents circulating through a wire of any metal, render this wire magnetic while the current flows, the magnetism ceasing the instant the current is interrupted.

By covering copper wire with silk we can wind a copper conductor, in a spiral, round a rod of soft iron. Let the copper wire be $\frac{1}{30}$th inch in diameter, the soft iron half an inch in diameter, and two inches long. Connect the ends of the spiral with a battery of one or more of Daniel's elements; the bar instantly assumes powerful magnetic properties.

Fig. 18.



Having tested the polarity of each end by the pocket compass needle, change the order of connexion with the battery, so that the wire which touched the copper shall now touch the zinc side—the poles of the iron bar will be found to have been reversed.

Break contact with the battery and all magnetism ceases in the iron.

Arrange two bars so that by a cross piece of soft iron and screws they can be placed in a Π form; contact with the battery gives each leg of the iron opposite and powerful polarity.

Apply a cross piece of soft iron to the poles, it is attracted so powerfully, that many pounds may be applied and sustained. The weight falls off when contact with the battery ceases.

Instead of soft iron apply sewing needles, pieces of clock or watch spring, or steel wires, to the poles of the iron magnet. On discontinuing the current and removing the steel this is found to be permanently magnetic.

By making the iron cross-piece open, so that the binding screws pass through it, as shown in the figure, the legs of this magnet can be adjusted to the length of the pieces of steel we desire to magnetise. By this very simple apparatus, and a battery of six Daniel's elements, we are enabled to prepare all the needles and magnetic bars required for use in our telegraph stations.

Soft iron thus excited is termed an *electro-magnet*. It is used in several most important instruments. It is the chief agent in the instruments used in France (Foy's), in Morse's, used in America, Prussia, and Austria; and in nearly all the alarms used in all countries. It is employed in the instruments patented by Allan, Highton, Dering, Brett, and others, in England. Its attentive experimental study is therefore strongly recommended. All the properties above described are susceptible of easy demonstration. The following laws should also be carefully learned:—

1. The magnetic force developed in the iron is in proportion to the quantity and intensity of the current.

2. The force, if the current be equal, is independent of the thickness of the wire or shape of the iron.

3. Within certain limits, in a continuous coil wound in layers, like a bobbin of silk, the external turns are as efficacious as those close to the iron.

4. The total action of the spiral is equal to the sum of the actions of each turn.

Thus, by increasing the force of the battery so that its intensity is augmented twofold, threefold, fourfold, the force of the electro-magnet increases in the same degree.

Whatever be the form of the electro-magnet, its force will remain the same so long as the intensity of the rest of the circuit is unchanged.

Electro-magnets wound with long lengths of very fine wire, say 1,000 yards on each leg, of insulated copper wire $\frac{1}{100}$ inch in diameter, are extremely sensitive to feeble currents, which if passed through thicker and shorter wires would fail to excite any magnetic action on the iron. On the other hand powerful batteries fail to excite great magnetic force if passed through fine wires. This is well illustrated in Morse's American Telegraph in which a *fine* wire electro-magnet receives the enfeebled current from the distant station, perhaps 500 miles off. This feeble current is just sufficient to enable the magnet to move a delicately balanced piece of soft iron. This establishes the contact necessary to cause a local and powerful battery to pass its current through a second electro-magnet wound with thick wire, $\frac{1}{30}$-inch, and the force thus excited is so great, as to cause a lever to strike powerful blows, indenting marks on bands of paper and knocking so loudly as to constitute a very efficient alarum.

The practical question of the length of fine wire to be used for telegraph instruments is one which will be better discussed in another part of this manual. It is necessary to advert here to the fact that in ordinary soft iron magnets there usually remains a slight degree of magnetism after the battery has been removed. This is termed *residual magnetism*, or polarity. It interferes much with the efficiency of many telegraphic instruments. It is generally believed to proceed from the presence of particles of carbon in the iron. M. Breguet accordingly submits all his iron to a very ingenious process, by which all traces of carbon are removed, and this tendency to residual magnetism thereby, according to his statement, entirely prevented. The iron is placed in a mass of powdered peroxide of iron, and kept at a red heat in a closed iron crucible for twenty-four hours. All the carbon is thus oxydised and removed, and perfectly pure iron procured.

To accomplish the same object Mr. Dering constructs his electro-magnets so that the length is not greater than the diameter, and makes them of disks of iron united by brass solder, and dispenses with the cross piece. M. Siemens uses hollow iron tubes slit open from end to end. Many other methods have been proposed by different experimentalists, most of which have

been tried fairly by the author of these instructions. In all the same result has been observed. The occurrence of residual magnetism was postponed, not prevented, and the power of the electro-magnet was much diminished, especially in Mr. Dering's and M. Siemens' arrangements.

It should not be omitted that M. Breguet winds his spirals round thin brass tubes, and into these drops the iron cores. Great mechanical facility is thus given for the immediate extraction of an electro-magnet which may have acquired this residual state, and for the substitution of one devoid of permanent magnetism.

Velocity of the Electric Current.

This question is one of the utmost scientific interest, and is not as yet completely decided. While Mr. Wheatstone estimates the swiftness of the current at 288,000 miles in a second; MM. Fizeau and Gonnelle declare it to be 100,978 miles per second in copper, and 57.789 miles in iron. The American experimentalists state it to be no more than 12,000 miles. As the lowest velocity is infinitely swifter than is required for telegraphic correspondence, we need dwell no longer on its consideration.

Chemical Effects of Voltaic Electricity.

To the preceding facts we have only to add a brief description of the chemical properties of the voltaic circuit, in order to prepare the student sufficiently for the duties he may have to discharge in the construction and working of telegraphic lines.

Fig. 10.

Let B be a battery of twelve couples of Daniel's elements; *z w*, the wire from the zinc side; *c w*, the wire from the copper side.

Let these wires terminate each in a slip of thin platinum. Let these slips be immersed in a glass of water rendered slightly acid by a few drops of sulphuric acid.

On contact being formed with the battery, streams of gas will arise from each platinum —from the zinc side hydrogen, from the copper side oxygen gas can be collected in tubes, and it will be observed that the hydrogen is twice the measure of the oxygen. Water has thus been decomposed into its elements, oxygen and hydrogen, by the voltaic current.

Let a solution of sulphate of copper be placed in the glass, instead of water: metallic copper will be deposited on the zinc side wire.

If iron or copper be substituted for the platinum plate of the copper side in a vessel of salt water, the iron or copper will be rapidly dissolved. If a little of the salt called yellow prussiate of potash be dissolved in the salt water previous to the immersion of the platinum and iron plates, and without the battery, no action is perceptible. But the moment the battery is applied, the iron plate causes the surrounding fluid to become of a deep blue colour, Prussian blue being formed by the solution of the iron combining with one of the constituents of the prussiate of potash.

If a copper plate be used, a fine chestnut-coloured compound is formed.

There are many vegetable juices which give a blue colour to porous paper, which colour is changed to a bright red by acids. The red hibiscus flower, common in every Indian garden, when crushed, gives a blue dye of this kind. Now, if paper be steeped in a solution of saltpetre (nitrate of potassa), and then dyed blue by the hibiscus, a slip moistened and laid on a piece of platinum, copper, or brass, connected with the zinc side of a battery, a platinum wire connected with the copper side of the battery, drawn over the moistened paper, will give a bright scarlet line wherever it touches, and produce no stain when the battery current is interrupted.

How these facts are applied in the telegraphs of Bain, Bakewell, and others, will be readily understood as we proceed.

PART II.

CONSTRUCTION OF THE LINES.

The lines of electric telegraph to be constructed in British India, as at present ordered, are to extend from Calcutta to Agra, following the valley of the Ganges to Allahabad. From Agra the line will proceed by Delhi to Lahore, a branch running from Umballa to Simlah on the Himalaya. From Agra another line will proceed, *viâ* Indore and Nassuck, to Bombay, and from Bombay it will extend across Central India to Madras.

The exact direction of the line in each province is still undetermined, but the total length to be constructed is about 3,200 miles of double line.

The countries to be traversed embrace great diversities of ground, elevation, and climate, from the almost absolute level adhesive clays, or loose sand of Bengal, to the precipices of the Himalaya at an elevation of 7,800 feet. In many districts great tracts of jungle must be passed through. Innumerable rivers must be crossed, scarcely any bridged; some—such as the Soane, the Hoogly, the Ganges, the Sutledge—equalling or exceeding in breadth the chief rivers of the American Continent. Along a great part of this immense line, from March to June the hot winds blow with an intensity which stops all day labour; from June to October the rains pour down at an annual rate varying from 78 inches in Lower Bengal, to 120 inches or more on the inferior ranges of the mountains. During this period terrific thunderstorms are of almost daily occurrence; and in May and October of each year a violent hurricane is calculated upon as a probable event Thus the efficient operations of engineering and field works are restricted to the fine season between October and March, five months at most; so that, omitting twenty-two Sundays, Christmas-day, and some native holidays of obligation, there are but 120 working days available in each season.

When to the natural and constant difficulties above specified we add the interruptions which in some districts and seasons

must be anticipated from the visitations of epidemic disease, enough has been stated to show that every person employed in the construction of the lines is entrusted with a duty which demands his most strenuous exertions. Accordingly men of strong constitution and steady habits are those only who can hope to retain employment. The duty is an arduous one, exposing all employed to a rough life and occasional privations and dangers. The indolent or unhealthy must fail in its performance, and such persons are accordingly warned of the uselessness of their seeking employment in these works.

The lines will be both overground and subterranean, in proportions to be decided by surveys now in execution. This chapter is devoted to the overground lines exclusively.

The overground lines to be constructed differ in several important particulars from those in England and Europe generally, chiefly in respect to the wire employed. This in England is No. 8 guage, ⅙th inch in diameter; 485 yards weigh 112 lbs., being about five miles to the ton. For India it is rather a rod than a wire. It is No. 1 in the Birmingham guage, and weighs 1120 lbs., half a ton, per mile. The difference has been sanctioned by the Government and the Court of Directors on the experimental evidence afforded by two lines of telegraph constructed by the author. The first, twenty-one miles long, of ordinary wire, was erected in the vicinity of Calcutta, in April, 1839.* The second, eighty-two miles long, extends from Calcutta

* The first line of overground line of more than one mile was erected in England four years later, in 1842; and in America six years later, in April, 1844. The patent for a mode of suspending wires in the air, was taken out by Mr. Cooke on 8th September, 1842.

The first overground telegraph line actually put in operation in the United States was an experimental one, ten miles long, erected between Washington and Bladensberg, in April, 1844.—Jones' Electric Telegraph, p. 66; New York, 1852.

"In 1839, Dr. O'Shaughnessy conducted an extensive series of experiments in India, with the view to ascertain the most suitable form of electric telegraph for that country. To Dr. O'Shaughnessy is due the carrying out of Dr. Watson's method, now so generally adopted in Great Britain and America, viz., of suspending the telegraphic wires in the air from post to post. Dr. O'Shaughnessy erected for his telegraph no less than twenty-one miles of wire; the wires were of iron. They were fastened to poles of bamboo, fifteen feet out of the ground, and were made to hang at distances from each other of about twelve inches.

"These important experiments of Dr. Watson and Dr O'Shaughnessy set the matter completely at rest, and rendered the idea of communicating

to Diamond Harbour and Kedgeree, crossing many miles of swamp and jungle, and traversing the Hooghly river 5,200 feet and the Huldee, 4,800 feet wide.

The reasons for adopting any special form of construction on the Indian lines are given in detail under each head as we proceed.

The lines now ordered are to be *overground* except where they traverse great towns, market places, and similar thoroughfares, where the subterranean plan will be followed. Rivers will be crossed wherever this is practicable, by wire ropes suspended from masts. When too broad for such suspension the wire will be led under water, protected by different methods specified in detail.

The construction of the lines involves three distinct stages.

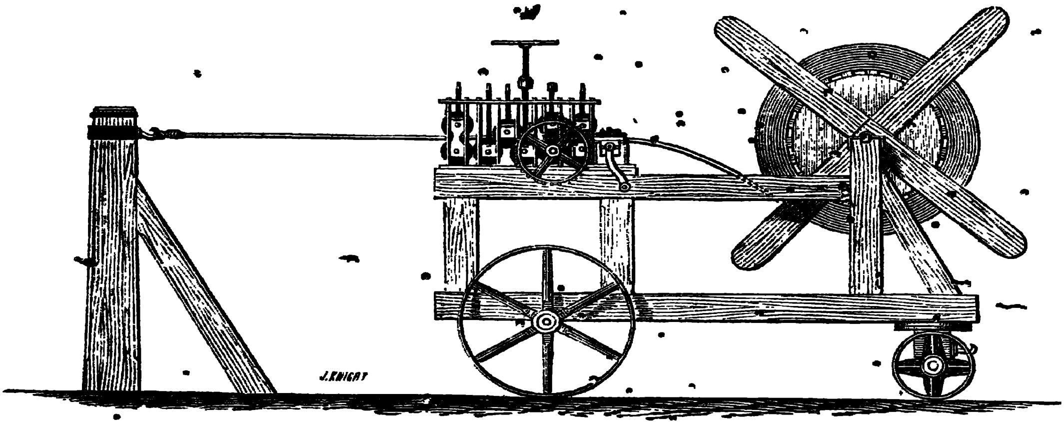
First, in order to open telegraphic correspondence as speedily as practicable, a single iron rod will be run across the country, supported on bamboos, palm trees, guran posts, and other *light and cheap* timbers available in the districts. On this line no insulators will be used, and temporary corresponding stations will be opened at such distances as experiment may prove that insulation can be dispensed with altogether in wet weather. This line will obviously be exposed to interruption by hurricanes, and will be to a considerable degree liable to injury by accident or wanton mischief. Nevertheless it will afford facilities for communication of very great value, and may be depended on for use on all ordinary occasions.

Secondly, the flying or temporary line is next to be converted into one of more substantial character. Sixteen lofty posts of the best timber procurable, each shod with an iron screw pile penetrating three feet into the ground, will be erected to each mile. On these posts insulating brackets of great strength will be secured, and the iron rod braced up by screws so as to be at the lowest point sixteen feet above the level of the ground, so as to allow of laden elephants to pass under the lowest part of the line.

Each post will be provided with a lightning conductor. In

intelligence between distant points, by means of electricity, no longer chimerical or doubtful, but a matter of absolute certainty."—*Aide Memoire to the Military Sciences*, part 2, vol. iii; London, 1852.

Dr. Watson's experiments were made in 1747, with two miles of wire, on Shooter's Hill, near London. Dr. Watson was the first to suggest the use of electricity for telegraphic correspondence.—W. B. O'S.


J.KNIGHT

this state the line will be secure from interruption by wild animals, and by the ordinary gales of each season. It will suffer little, if at all, from lightning; and, indeed, will be liable to few interruptions but what may be caused by the wantonness or malevolence of man.

Thirdly, the lines will be completed by the erection of a second rod, so as to permit of the use of double instruments, and to meet all the wants of the public and the Government. The stations of correspondence will be multiplied, and all the experience gained during the first and second stages of the construction applied to render this as permanent as possible.

Assuming the requisite supplies of stores to be distributed so that field work may commence in October, 1853, there should be no difficulty in constructing one mile of the flying line daily by each working party during the fine season. Three-fourths of the whole line may thus be constructed by twenty parties in the first fine season, leaving one-fourth to be completed by night work from time to time, during the unfavourable months.

FIRST STAGE—CONSTRUCTION OF FLYING LINE.

This will consist of a single rod of $\frac{5}{16}$ inch galvanized iron, extended on bamboos, palm-trees, guran posts, or any similar cheap timber procurable in each district.

The iron rod weighs 1,120 pounds per mile. It is obtainable from the arsenals in coils four feet in diameter—each coil containing one quarter of a mile of rod in one length.

The bamboos or similar posts, previously painted with coal tar, are to be planted 50 feet apart, three feet deep in the ground. The loftier the post the better.

Each coil of wire is unrolled and delivered in a straight length by a machine,* one of which will be supplied to each working party. Of this machine a drawing is given in detail.

A circular frame or drum, on which a coil of iron rod is placed, is supported on upright bearings, so that it can move in a vertical plane; one end of the wire is inserted in the opening formed by the grooves on two horizontal rollers of hardened steel; the end of the rod, being drawn through, is secured by a chain and eye-bolt to a tree, or stake, or post, firmly planted in

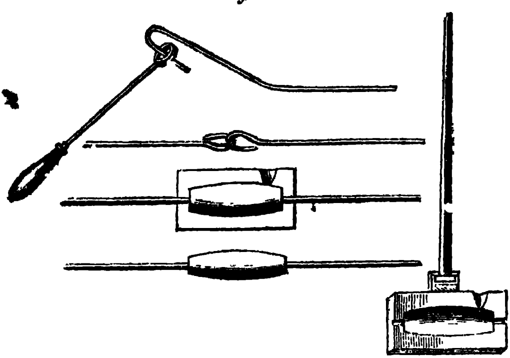
the ground; and a party of three men then draw the carriage on which the machine is mounted, in the direction in which the rod is to be laid. This machine, by the labour of four or five men, delivers the wire straightened, at the rate of eight to ten miles a day.

When the first coil is unrolled, a second coil should be mounted on the drum, and its end jointed to that of the rod just straightened by the zinc ingot joint next to be described.

Zinc Ingot Joint.

A hook is turned on each end of the rod by a strong iron eye-bolt, into which the rod is inserted for about six inches. By bending the rod a loop is formed. This loop, cut across by a steel chisel, gives the link, thus:

Fig. 20.



The hooks are then crossed, and the ends hammered down close; the hammered bends must now be closely examined, and if any cracks be detected, the piece must be cut off, and a fresh hook turned.

The link is now inserted in a mould, like a bullet mould, formed of two pieces with a cavity in each, and with hinges and handles, to admit of its being opened and shut at pleasure.

The mould being closed, melted zinc is poured into it through the opening, and the whole allowed to rest for two minutes, when the mould is opened and the ingot trimmed by the chisel.

The quantity of zinc required for each joint is one pound two ounces. The mould previous to the casting should be carefully dried.

The zinc is to be melted in an iron ladle on the common native forge, with which each party will b. provided.

The strength of this joint is so great that the iron rod exposed to strain will break more readily at any other place.

It is desirable to extend the line on the ground as straight as can be, and to make all the joints for a length of four or five miles before the rod is lifted on the posts, and the *suspension* on the poles *should commence in the middle of the line.* The great mass of metal at each side thus equalises the tension, and a nearly horizontal line is obtained on posts even 100 feet apart, without the necessity of using any bracing screws or other straining power.

The iron rod in this flying line rests simply in a notch cut on the top of the bamboo, or in a groove in the palm tree or other timber post. The erection of the bamboos, palm trees, and other temporary posts, will be in all cases best managed by the village house builders (*bildars* and *gramies*), a gang of which men, consisting of a *sirdar* and ten men, should be entertained with each working party.

Great care should be taken to keep the line removed as far as practicable from the proximity of trees, by the fall of which it might be injured. This will often necessitate its being led off the great roads, on which the timber is too valuable for its shade to be sacrificed for the telegraph line.

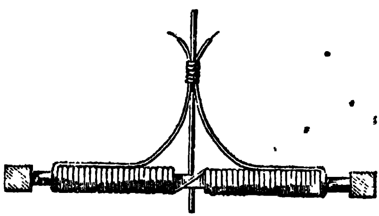
In constructing this flying line, each day's work must be tested by the European sergeant in charge of the party with reference to its perfect conducting power, by telegraphic signals previously arranged with the persons remaining at the place from which the line commences.

The portable telegraph for testing the line, and for the use of the working parties, is described under the head of "*Instruments.*" Sixty European sappers and Artillery-men have been trained to its use at Warley, and three of these men will be employed with each working party.

Before the season of thunder-storms approaches, the office or

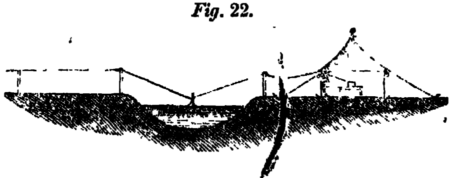
tent at each end of the flying line should be protected from lightning by the following simple method:—Ten yards of the copper wire covered with gutta percha used for subterranean lines, and covered with tape and tar, as subsequently described, are wound in a spiral coil round a piece of light round wood; the ends of the wire turn up and are attached to an upright stick; the coil-piece has two cross pieces of light wood nailed to each end. The telegraph rod is then connected by a copper wire to one end of the coil; the instrument in the office is joined to the other, care being taken that the wires of opposite ends do not come in contact; the whole is then floated on the surface of the

Fig. 21.



tank or well which supplies the post with water. A flash of lightning striking the line, having to traverse this coil, will explode through the gutta-percha to the water, and only so small a portion of the electric fluid will pass into the office as can cause no injury to the signallers or instruments. After such an explosion the gutta-percha coating will be found to be torn through for some inches. This portion is to be unrolled, so as

Fig. 22.



to bring it above the surface of the water, and the conductor replaced as before. The whole arrangement is shown in the annexed cuts.

SECOND STAGE—STRENGTHENING THE FLYING LINE.

To accomplish this object, sixteen strong posts of the best timber procurable are erected at intervals of 330 feet. The most durable timber which can be procured is to be employed, and measures are now being taken to obtain an adequate supply of the iron-wood of Arracan, which is known to be almost indestructible by damp, fungus, or insects. It is so hard as to be cut with difficulty by carpenters' tools. Being of great weight, its transport in many places will be tedious and costly. This timber will be used as much as possible in its natural form, unsquared, in posts 24 feet high, 5 to 6 inches diameter below. The thick end is to be tapered by the adze and plane, so as to fit closely into the hollow iron screw pile, in which it is to be inserted in the ground.

Where iron-wood is not procurable, or cannot be conveyed, teak, saul, or any other good timber, may be used. In the mountains oak and pine will often be available. Deep-rooted trees occurring on the line may be used freely, the tree being killed by the removal of its bark, and all branches lopped off. The toddy palm tree may in many places be used with great advantage. Each post is to be branded with a number and letter in a conspicuous place.

Previous to being placed in the iron screw pile, an insulating cap and bracket is to be securely attached to each post, thus:—

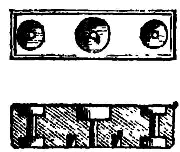
The post is tapered so as to be 2½ inches in diameter at the small end, and 3 inches in diameter at 7 inches from the top. The wood is to be roughened with a chisel so as to hold the cement by which the cap is to be attached.

The cap (*Fig.* 23) is of wrought iron, galvanized, 8½ inches high, 10½ inches in circumference above, 12½ inches in circumference below, its lower edge or rim everted to 13½ inches, closed above, and perforated to permit the passage of a screw bolt 4 inches long and ½ inch in diameter. Two strong metal studs, ¾ inch in diameter, and 1 inch long, are riveted on the cap, one at each side of the screw, for the purpose of preventing lateral motion of the bracket to be afterwards applied.

The cap being inverted, the cement is thus applied. Three parts by weight of fine, clean, and perfectly dry sand, with one part by weight of the best pine rosin, are melted in an iron pot, and well incorporated by stirring. The consistence should be that of thick mud. Enough of this cement to occupy half-an-inch of the cap should be poured in and allowed to cool, which takes about five minutes.

Fig. 23.

Fig. 24.



The post is now inverted, and its small end placed on the hardened cement, so that a clear space of half-an-inch remains between the wood and the cap all round. Melted cement is now poured in, so as to fill up this space up to the brim. As the cement cools, it contracts slightly, so as to become concave. The post must be kept perfectly steady while the cement is cooling and setting, which occupies about five minutes. It is now ready to receive the bracket.

The quantity of cement used for each cap is 1 lb. 14 oz.

The bracket (*Fig.* 24) is of oak, 11 inches long, 4 broad, and 3 deep, perforated in the centre for the passage of the cap screw, also perforated at 1½ inches from the end for the passage of the binding screws for the attachment of the iron rods, and having on its lower surface two cavities, 1 inch deep, ¾ inch wide, to receive the studs of the cap. On the upper surface a circular hollow is sunk at each end, ½ inch deep and 1½ inch in diameter, to receive the necks of the porcelain insulators, subsequently described.

The bracket is now placed on the cap, so that the studs sink into the holes to receive them, and the nut is firmly screwed down, so as to countersink in the substance of the bracket.

The post is now ready to be mounted in the screw pile; but it is more convenient to describe in this place the application of the insulators to be used on the final completion of the double line.

Fig. 25.

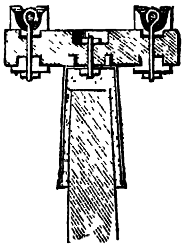
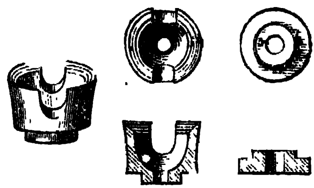


Fig. 26.



The *insulators* (*Fig.* 26) are of brown stoneware, glazed, and consist of two pieces. The larger, of the form shown in section in the cut, is 3 inches high, including the neck; 2½ inches in diameter above; the neck 1½ inches diameter, perforated vertically to allow the passage of a ½-inch screw, traversed by a groove ¾ inch wide, and 1 inch deep, to receive the telegraph rod, and hollowed out internally, so that after it is in its place, and its binding screw secured, the cavity may be filled with the melted cement previously described.

The insulators are placed in the brackets, as shown, and their binding screws put in loose, ready to be used when the line rods are set in their position.

The line binding screws are 5 inches long, of ½-inch iron, galvanized. They clasp the lines securely in their place.

These insulators are not, however, to be used on the line in the second stage. This, it is to be remembered, affects only the erection of a single line, for which the metal cap insulator is sufficient; but in this case the bracket requires to be surmounted by a piece of wood two inches thick, fastened by screws, and grooved on its surface. Into this groove, precisely over the centre of the post, the line rod is placed. It requires no binding screw in this stage of the operations, but a second piece of wood should be cleated down on the first, after the rod has been placed.

Screw Piles.

Iron screw piles are used for the double purpose of protecting the timber from decay and insects, and for the great strength they afford in resisting displacement by shocks and strains of every kind. While two men can readily pull down or displace a post of equal size implanted in the earth without a pile, ten men cannot accomplish this when the screw is used, without the aid of shears and tackle. The screw pile also greatly facilitates the erection of the posts.

Fig. 27.

The screw pile to be employed (*Fig.* 27), ***Mitchell's patent***, is 3 feet 1¼ inches long, and 7½ inches in diameter above, hollow, conical, its head six-sided externally, round internally; thickness of iron, ⅜ inch. It tapers to a point below. The screw flange commences close to the point, and making three turns, terminates 10 inches above the point. The diameter of the screw flange at its greatest width is 12 inches.

The pile is screwed into the ground, by a wrought iron bar, with a four-sided opening at one end, in which the neck of the screw is received. This is called a "spanner." It is 9 feet long, and fits closely to four sides of the hexagon head of the screw.

The "spanner" is worked like a capstan bar, and is very efficacious while the pile is not more than 18 inches in the ground. As it is then below the easy reach of the men, in this case a round iron plug, slightly tapered, and having a hole through its diameter, is inserted in the head of the screw, so that the hole corresponds with one in the neck of this. The plug is then keyed or bolted into the pile, and square-headed spindles, one, two, and three feet long, are successively inserted in an aperture in the plug. The moving power is applied to the spindle by a cross-bar or lever of wrought iron, 10 feet 8 inches long, having a square hole in the centre to receive the head of the spindle.

To screw down a pile, a party of nine men is required. One of the men commences by making a hole in the earth with a crowbar. This hole need not be very deep, but, if the ground is hard and pebbly, it must be 2 to 2½ feet deep. The screw pile is then placed quite upright, with its end in this hole, and the lever or spanner fixed on the pile to screw it round. Four men are required at each end of the lever, and one man should carefully attend to the screw, watching whether it goes down straight. Everything being ready, the men now go round steadily and slowly; there must be no hurry, and care must be taken to work the lever as horizontally as possible. If the men press downwards at one time more than another, the pressure will make the screw go crooked. It is also a great object not to let the pile "wabble" about at first, since this loosens the earth.

If the ground is very stiff, and the screw bites imperfectly, it may be taken up, and the hole made somewhat deeper with the crowbar, or a pailful of water may be thrown into the hole, and one or more men should stand on the head of the pile, the penetration of which is much accelerated by their weight. It is essential that the screw pile should be driven in straight, because the least deviation will make the post, when fixed in it, deviate from the perpendicular. The man who watches the screw must attend to this; if he sees that it is entering crooked, he must sit nearly on the ground, place his arms round the screw pile, plant his feet firmly before him, and thus draw the pile to the straight position.

If this fails, then the men must, as they go round, press down on that branch of the lever which is opposite the side towards which the screw is beginning to lean; or the pile must be unscrewed one or two turns, and thus got in straight. Two men at each end of the lever will be enough at first, but as the screw goes down the whole four must work it, and the men should remember that the nearer they push to the end of the lever which is away from the pile, the more effective will be their power.

The pile having been screwed into the ground within 6 inches of the top, the posts are now to be erected, the intervals being exactly 330 feet, or half a furlong—16 to the mile.

This interval has been chosen after careful trial. At that distance the iron rod employed can be braced up with ease by the straining machine afterwards described, so that the deflection from the horizontal line is no more than 18 inches, being scarcely perceptible to the eye. At this span three men, weighing in all over 30 stone (420 lbs.) have been supported on the rod in the centre of the span without causing it any injury.

A certain number of posts, say 100, being erected, the iron rod is lifted from the nearest bamboo and placed on the centre of the permanent post. This operation should commence *on the middle of the line*, each end of which should be previously secured to a tree by a chain, or to a log of timber, 8 or 10 feet long, placed transversely in a trench four feet deep, and the earth rammed in. These fixing points at the ends are to be but in temporary use while the rod is being equally suspended on the posts.

The bamboos or temporary timber posts may be now removed, except one in the centre of the span, 165 feet from each pile. This intermediate light post may remain while trial is being made of the greatest distance through which signals can be conveyed through a line thus constructed. Where the iron rod rests on the intermediate bamboo or other temporary post, it is to be insulated by being coated with a spiral layer of silk, saturated with lac solution—thus :—

A strip of the strong and cheap silk from Assam, Bagulpore, &c., 1½ inch wide and 36 inches long, is saturated with a solution of shell-lac in wood naphtha (pyroacetic spirit). This strip of silk is wound round 24 inches of the rod smoothly in a spiral, overlapping one-half in each turn. This is repeated till a double layer is formed.

When this dries, it constitutes a flexible non-conducting coating, which does not soften by the sun's heat, and is not affected by rain.

This silk and lac coating is also given to the rod where it rests on the permanent posts.

When a supply of the silk and lac solution is not procurable, Madras cloth, or any similarly strong and porous fabric, may be used instead, being saturated with pitch softened with a small

proportion of tar. This is, however, by no means equal to the silk and lac envelope.

The rod, having now been placed in its position, is to be cleated down on the bracket and secured by four screws, one in each corner of the cleat, great care being taken that the screws do not touch the iron rod.

The post and bracket should now be painted with a mixture of Gurjun oil and any of the *earth* paints, such as the *Geru mittee*, or coarse Armenian bole, common in the Indian bazaars. Coal tar may be used, but white-lead, copper greens, or other metallic paints, should be carefully avoided.

A *lightning conductor* is next to be attached to each of the permanent posts. This conductor consists of a piece of iron rod, the same as the line, inlaid in a groove in each permanent post, penetrating between the post and the screw pile for at least 6 inches, and 6 inches below the metal cap turning outwards, so as to keep 6 inches clear of the line rod, and then project 6 inches above the post. The conductor is secured in its place by three iron staples driven into the post at equal intervals. The ends of the lightning conductor are to be pointed and tinned. If galvanised iron be not available, common iron rod, painted with coal tar applied hot, may be used instead.

Besides this conductor attached to each post, each river line, every office, and all the instruments, have special forms of protectors, which will be subsequently described.

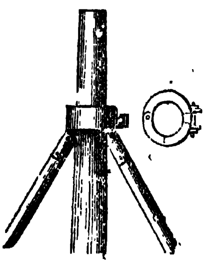
THIRD STAGE—PERMANENT DOUBLE LINE.

A double line is regarded as essential, finally, to allow of the use of instruments, which cannot be worked with a single line—to permit of long or through correspondence with distant places, free from local interruptions—and to enable one line to be exclusively devoted on certain occasions to the transmission of the despatches of Government and of public departments.

The extension of the second rod is effected, as in the case of the first, by the straightening machine already described. When the joints are all made, the rod is to be lifted on the bracket, and the first rod removed from the centre to one side, where it

will rest on the groove of the stoneware insulator, the binding screws being dropped in loose; and preparations are now made to apply an equal strain to both rods, so as to bring these into a parallel and level state.

Fig. 28.



Wherever a strong tree is available, it can be made use of in the straining operation. If it be necessary to strain on one of the line-posts, four strong props should previously be applied, to prevent its being drawn out of the ground. The post is on no account to be notched for the props, but a cast-iron clamp is to be screwed round the post, against which the props may lean. A post, the collar, and two of the props, are shown in the accompanying cut (*Fig.* 28).

The operation of straining is very greatly facilitated by the use of temporary intermediate props. As the flying line will afford a large supply of bamboos or other light timber, these may be used crossed, like "shears," or the supports of lines for drying linen. The greater the number of these employed, the easier is the straining, and the less is this liable to injure or dislocate the permanent posts.

It is necessary to state here as prominently as possible, for the guidance of the artificers trained this year at Warley, that the strong straining posts of oak, of which four were used on the experimental lines, were employed solely on account of the shortness of these lines, and such will not be used in India. It is the more necessary to advert to this, as the straining posts at Warley were all perforated for the passage of the rods, while no perforation can be permitted or is required in India, where the length of the lines allows of the straining being commenced in the centre, not at the extremities, and the flying line affords such an abundance of temporary props as almost to render straining unnecessary.

When required, it is best performed by the erection of a temporary but very substantial straining post of saul or teak

timber 7 or 8 inches square. One of these, placed on a truck with four wheels, should accompany each party. The beam is 22 to 24 feet high, shod by a screw pile 6 feet long, and has two grooves at top, 4 inches deep, to receive loosely two double-eye bolts, each 12 inches long, of half-inch galvanised iron. The post is erected under the lines at a place convenient for the erection of the scaffolding, and at the lowest part of the line to be braced up. The post is screwed 6 feet in the ground, and its top rises *between* the two line-rods, which are then firmly clamped to the post by two powerful screws, which pass through it from side to side. The screw-clamps are 4 inches apart, and a wedge of iron is driven in between, to aid in preventing the slipping of the rod.

A platform or scaffold of loose poles and boards is now erected about the post to support the workmen and the straining apparatus. The post rises *above* and *between* the rods *to the height which the line is to be when braced tight up.*

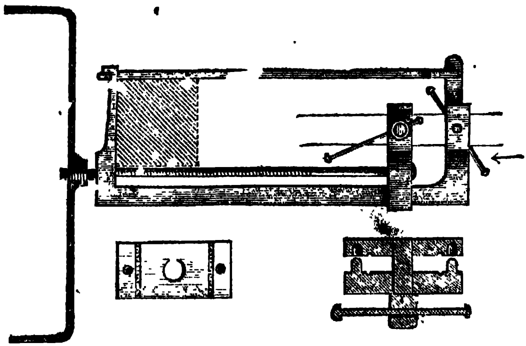
A straining screw and vice, shown in detail in the cut (*Fig.* 29), are now secured on the post below the eye-bolts by the iron arm, and both line-rods are seized in the jaws of the double vice, which is then screwed up by the winch, thus bracing the wires two feet. The jaws of the stationary vice, through which, previously loosened, the rods have moved freely, are now tightly screwed together, so as to retain the rods while the main screw and moveable vice are loosened and returned for another journey.

The portions of the rods between the moveable arm and the post are now in loose loops between the post-clamps and the stationary vice. By relaxing one of the post side-screws, the loop may be brought up so that it can be cut in the centre between the side-screws, and each end be passed through the eye-bolt resting on the groove at the top of the post.

A second journey of the bracing screw should now be made, the portion of the rod gained secured, and the apparatus turned in the opposite direction, to strain on the other side. This alternate straining should be carried on till the line is braced, so that the lowest part subject to the strain shall be 16 feet clear above the ground.

Temporary props being now placed under the lines near the straining post, *this is removed.* The ends of the rods are turned into hooks on the eye bolts, and an ingot of zinc is carefully cast over each hook, in the manner already pointed out.

Fig. 29.



The temporary props and scaffolding are now to be taken away. This straining operation is to be performed as sparingly as possible. Moderate curves on the line are not objectionable. All that straining is required for is to elevate the lowest part above sixteen feet from the ground. The application of the straining apparatus once in a mile will be amply sufficient.

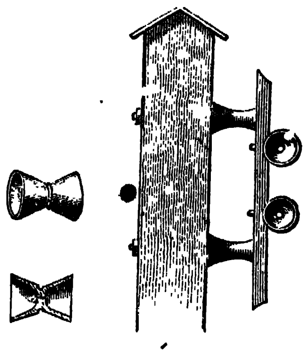
During the straining, men should look carefully along the posts, half a mile at least at each side, to prevent any locking of the rods on the insulators, or distortion of the brackets and caps. When the bracing is complete, the screw bolts on the insulating caps should be screwed tightly up, and melted cement poured into the cavity; finally, a layer of cement, one inch thick, should be poured all over the top of the bracket.

OVERGROUND LINES IN ENGLAND.

The English overground lines are constructed in all instances along railways. The wires are of "best common" iron, galvanized, five miles to the ton. The posts are of fir or larch, 50 or 60 yards apart, from 10 to 25 feet high, 4½ to 6 inches in

diameter, penetrating 3 to 4 feet into the ground. At every quarter-mile, on several lines, are straining posts, 7 to 10 inches square, with ratchet-wheel winders for tightening the wires.

Fig. 30.



In the lines constructed by Mr. C. V. Walker the distinguished superintendent of the South-Eastern districts, the wires are attached to the posts by side brackets, as shown in the drawing (*Fig.* 30). Mr. Walker's insulators are of brown salt-glazed stoneware, of the hour-glass shape shown. Through these the wire is threaded, and is braced up tight without any fastening. The insulator itself is bound to the bracket by several turns of wire passed outside the narrow part of the insulator, and entirely unconnected with the telegraph wire within.

Mr. Walker has lately enclosed the wires and insulators, where no more than four are used, in a thin wooden box, like a pigeon-house—and this system, he informs me, gives more effective insulation.

The chief objection to the hour-glass-shaped cones is their liability to fracture. Every severe storm displaces them in varying numbers, and then the line must be cut to thread on new cones or a much weaker form, open at the side, must be employed.

In India this form of cone could not be employed, with reference to the weight of the iron rod, and the means of fastening this at each post. But there is another objection—in the liability of all such hollow cones and similar openings to be built up by spiders, ants, wasps, and countless other insects, some almost microscopic, which fill up almost immediately every tube or crevice to which they can gain access.*

* Blowpipes, clarionet reeds, mouth-pieces of pipes, &c., left on a table for a few days, are commonly found to be filled up in this manner.

The pigeon-house tops would be objectionable with us, for the accommodation these would afford to sparrows, the Indian minah or starling, to squirrels, tree snakes, &c. Even on the Hastings lines the writer has seen the straws of sparrows' nests protruding from more than one of the boxes.

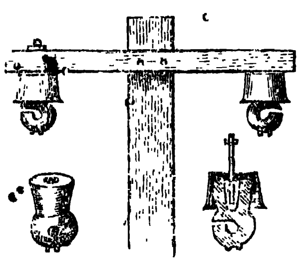
Mr. Walker's ingenious lightning protectors will be more appropriately described under the head of Office arrangements.

On the Eastern Counties, Great Northern, North-Western, and Southampton lines, and all those under the management of Mr. Edwin Clarke, the lines, as regards the posts and wires, differ in no important degree from those just described.

The wires are attached to cross brackets, as shown in the figure.

The insulator is a very strong stone-ware hook, open at the side (see *Fig.* 31), so that the wire can be placed on the hook without threading, and the hooks can be replaced in case of breaking, without cutting the wire. This is further securely fastened to each insulator by turns of thinner wire, twisted round the hook and line wire, like the wires on a soda-water or champagne cork round the neck of the bottle. They are also further secured by solder.

Fig. 31.



It is attempted to keep the neck of the insulator quite dry by an inverted cap of zinc (*Fig.* 31), and the efficacy of this arrangement is strongly asserted, especially with reference to dews and fogs.

On Indian lines these zinc caps could not be used, on account of the objections already described in noticing the hollow cones adopted by Mr. Walker.

On many of the English lines the traveller notices a great number of wires. These are used either for as many different stations, for each of which a constant communication may be

desirable; or to enable, on busy commercial routes, double or treble, or even tenfold, the messages to be transmitted which a single line could convey.

The English lines are, on the whole, too slight and fragile for imitation. Every gale damages them in exposed situations. The joints in the wires are, generally speaking, made with but little care. On every line the writer has examined he has, in many cases, seen joints merely of twisted wire without solder. The association with railways is, mostly, a cause of very common interruption. Every time a carriage or engine gets off the rail the telegraph lines are damaged; and it thus happens commonly that when their functions are most urgently required no signals can be transmitted. The insulation is very imperfect, much inferior to that in France and Prussia; and the distance of direct communication in bad weather much shorter than need be the case were a better system adopted.

In the lines between Dublin and Galway, Mr. Henley employs insulators of thick *gutta-percha* plates; but as this substance softens to the consistence of honey under an Indian sun, this method requires no further observation here.

All the above objections are so strongly felt—with reference, moreover, to circumstances detailed under the head of the *subterranean* lines—that there is now a strong tendency in England to abandon altogether the present mode of construction—to adopt the subterranean plan—or to make use of the common roads, employing lofty posts, and more substantial materials of every kind, as we shall presently find is done in Prussia, and still more remarkably in Piedmont and in India.

The total length of telegraph lines in England in August, 1852, was about 3,300 miles, extending from Dover and Plymouth, on the south, to Dundee and Glasgow, on the north, and from Lowestoft, in the east, to Holyhead, in the west.*

FRENCH LINES.

The following remarks on the construction of the French lines are founded on observations made, under full official facilities

* *British Almanac*, 1853, p. 34.

on the lines connecting Boulogne and Paris, and Paris and Strasburg.

The lines are all overground, except in the principal cities, of galvanized iron, No. 8 gauge, supported on fir or poplar poles from 12 to 30 feet high, planted 4 feet in the ground, the poles pickled in a solution of sulphate of copper, which, by the experience of six years, has been found a perfectly efficacious preservative. The poles are painted a pale yellow colour, and are 150 feet apart. The number of wires is never less than two, but several wires are frequently supported on the same poles.

In Paris, for the local service of the ministerial offices—the police, the fire brigades, and the military posts—wires are led at immense spans over the houses and streets, across the squares and the river, the distance, in some instances, being over 500 yards—for example, in the span from the Prefecture of Police across the Seine, to the corner of the Mint.

Along the quays, from the esplanade of the Invalides to the fortifications, the lines are erected on light cast iron columns, 12 feet high, let into the stone masonry of the parapets, and each column carrying a top of ash or other tough wood, six feet high. On this wooden piece the insulators and wires are supported. The average cost of each of these compound pillars is 120 francs, say £5. The weight of iron is 233½ lbs. avoirdupois.*

Insulation.

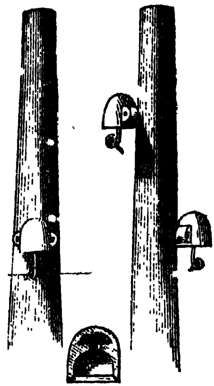
On all the French lines insulation is now effected by means of inverted cones of white porcelain, 2½ inches deep, highly glazed. Within each cone an iron hook is inserted, on which the line wire is suspended. The hook is twisted once or twice round the wire, so as to secure this from displacement by lateral strains. The iron hook is cemented into the cup by sulphur, for which M. Vinchent, the director of the Belgian lines, has judiciously substituted a cement of sulphur and iron, which sets to the

* The extraordinary rise in the price of iron since August, 1852, renders it difficult to set a fair value on iron work at present, but in common states of the market the posts above described might be cast and shipped for fourteen shillings each.

hardness of stone, and possesses great mechanical strength, in which sulphur by itself is deficient.

The effect of these insulators is excellent. The inverted conical form causes rain to run off, leaving the inner surface dry. The white colour and high polish prevent the deposition of dew which takes place so rapidly on brown glazed stoneware. The price is, further, very moderate —3d. to 4d. each, delivered at Bordeaux.

Fig. 32.



The insulation effected by these cones is so good, that as the writer has himself witnessed, Paris communicates in the heaviest and most general rain with Strasburg, 312½ miles, with Brussels, 231¼ miles, with Bordeaux, 284 miles, without repetition of the signals on the way. This is the more remarkable as the instruments used are by no means sensitive, and the batteries not more than 40 couples of the carbon, or 60 of Daniel's elements.

The insulators above described are not strong enough for heavier wires than those used in France; and as many circumstances, afterwards explained, lead to the use in India of metal nearly four times more massive, the French cones cannot be used except in some short local lines, or for river crossings.

Lightning Conductors on the Lines.

Besides the lightning protectors for offices and instruments to be subsequently noticed, M. Foy, the eminent Director General of the French Telegraphs, has introduced several admirable contrivances, some of which have not been described in print, and all of which he kindly permitted the writer to examine in detail, and describe in these pages.

To guard the *lines* from lightning, at every fifteenth mile an

iron post is erected, carrying an iron plate, having as many round apertures as there are wires, and through these apertures the wires pass without touching. Lightning striking the line having to pass through these holes, flashes off to the iron plate, and thus escapes harmlessly to the earth.

This contrivance is further found, according to M. Foy's experience, to intercept to a great degree the natural and induced currents of electricity flowing through the lines.

This is an object of great importance. In India we have found that in all the telegraph lines running north and south, in the finest as well as in bad weather, a strong natural current of electricity is always flowing in the lines. This current deflects the needle of the galvanometer telegraph hard up to the west, and is accordingly the same as one from the zinc side of a battery. It is strong enough to give magnetism to soft iron, and when reversed it strikes deep blue stains on chemically prepared paper. On the east and west lines it does not exist, as far as our opportunities for observation have extended.

Again every distant thunder-cloud affects the line by *induction*, and every flash of lightning within at least fifty miles, without striking the line, causes an instantaneous wave of induced electricity to flow through the telegraph system. This wave is often so intense as to cause very startling effects in the offices—sparks snapping with the noise of detonating caps—smart shocks to incautious assistants—deviations and derangement of the needles—and permanent polarity in the electromagnets. The alarm bells are thus commonly rung at night by the *induced* effects of thunder-clouds, the lightnings of which are not visible at the station, and which do not even approach the telegraph lines.

The line and induced currents now described have caused great difficulty in all the first trials of the Indian telegraphs. Under the head of instruments this will again come under notice. M. Foy's system seems likely to conquer the difficulty altogether. One of the first special experiments to be made on the Indian lines will accordingly be the trial of a sufficient number of the *interceptors* on M. Foy's method.

But as lightning discharges can never be *totally* withdrawn or

carried off by any lateral conductor, M. Foy provides the outside of each *office* with a special apparatus of much efficacy.

A box of cast iron, 18 inches square, opening in front, is provided with wooden shelves, one for each line. The box is connected with the earth by a rope of iron wire led into a well, and ending in a copper plate. On each wooden shelf a thin copper wire is arranged so as to give about 100 turns, at each of which it presents an acute angle close to the side of, but touching, the iron box. A lightning charge entering the box has to travel to and fro on this line, and at every turn the sharp points give off a portion of the charge to the iron box, and *nearly* the whole thus passes to the earth before it can enter the office.

In the offices further precautions are adopted for each instrument, which will be subsequently described.

A certain number of M. Foy's iron boxes will be provided for trial and observation on the telegraph offices at present open in Bengal.

It is, at the same time, but fair to state, that up to this time the arrangements on the Calcutta lines have sufficed to guard the offices and signallers against all serious injury, although a single north-wester exposes them to greater danger than would the storms of an entire year, such as those experienced in England or in France.

Lines on Common Roads.

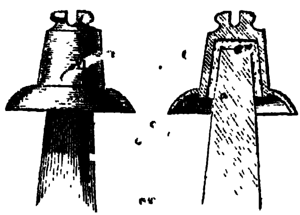
Several lines exist in France on common roads. The poles in such cases are much higher than on the railways. Interruptions are seldom suffered, even in periods of great political commotion. On common roads a watchman is employed at every ninth mile.

The crossing of rivers is in France invariably effected by lines led above water and along the parapets of the bridges. The Rhine is crossed at Strasburg on posts erected on the ice-guards *(brise-glaces)* above the bridge of boats, between Kehl and the French side.

THE BADEN LINE.

This at present extends from Manheim on the Rhine, *viâ* Carlsruhe to Kehl and Strasburg. All despatches from Trieste for Paris and London now come by this route, and are repeated eight times on the way.

Fig. 33.



The line is of copper wire, the posts very slender, and of the most common wood, unpainted, but 100 feet apart.

The insulators are of a very coarsely glazed earthenware, cemented on the top of the spar by plaster of Paris. The wire is twisted round the neck of the cap. Where two wires are in use, one is carried on an iron bracket at the side of the pole.*

Baden Lightning Conductors.

These are on the plan devised by Steinheils of Munich, several years ago. Similar contrivances on a much smaller scale have lately been patented by Mr. Dering in England. The officers in charge at Carlsruhe speak of their efficiency in high terms.

Two brass plates, each 8 inches in diameter, and each connected by a strong wire with the earth, are placed, one at each side of, parallel to, but not touching, a similar brass plate connected to the telegraph line. Lightning discharges explode across these plates and proceed by the outer ones to the earth without causing injury to the line, station, or instruments.

These plate conductors are used at each station, and placed just over the door, so as to be sheltered from rain and to be easily accessible.

* These insulators are good in principle, but the material very bad. Mr. Bourne, of Macclesfield-street, City Wharf-road, London, now makes them, from the patterns given him by the writer, of the finest brown stone-ware for 5d. each.

A very simple modification of this apparatus is used in the Indian offices, and is described under that head.

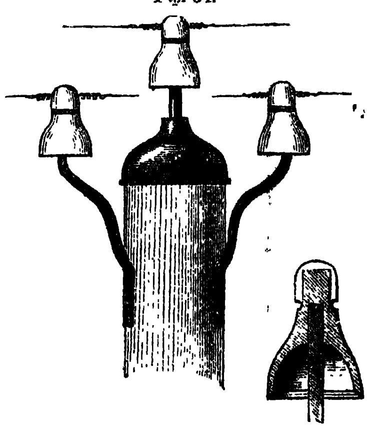
Frankfort to Mayence.

The Baden line terminates in one direction at Frankfort, from which city a short branch extends to Castel, opposite Mayence. The line is constructed in a very faulty and objectionable way. The posts are short, slender, and weak; the line, a single copper wire, unstrained, in many places hanging loosely u... the posts. For insulation the wire rests on a notch on the top of the pole in a fold of India-rubber. A piece of painted tin plate forms a pent roof over the entire. No lightning conductors are seen along the line. On the whole, this was the worst line which came under the writer's notice.

THE PRUSSIAN LINES.

These are admirably constructed in every way, and are well seen at Deutz, opposite Cologne, from whence the system radiates to Hanover, Belgium, and Berlin. One of the most interesting branches is the one now in construction from Cologne to Ehrenbreitstein, opposite to Coblenz, along the common road, and about 60 miles long. It is intended chiefly for the transmission of military despatches, and for correspondence between Berlin and the King's summer palace at Stolzenfels on the Rhine.

Fig. 31.



The line is triple; the posts 20 feet high, 6 inches diameter, 120 feet apart, of the best timber, painted above ground, charred where they enter the earth. The insulators are of white

porcelain, 4½ inches high, 3½ wide below, ½ inch thick, very strongly supported on thick iron brackets, in the manner shown in the annexed figures. Each post carries a lightning conductor of pointed copper wire, connected with the ground.

In solidity and insulation these lines are the best the writer has seen, and are stated, on high authority, to be the strongest in Europe. Twelve carbon elements, without nitric acid, work the American instruments between Cologne and Berlin, 390¾ miles, without repetition of the signals. It is gratifying to add, that in massiveness and strength, and quality of material, the Indian lines will still far exceed the Prussian, leaving but little doubt of our communicating distances, without repetition, extending to a proportionately greater length.

BELGIAN LINES.

At Verviers the Prussian system terminates, and we again meet that of France. Belgium has no special system of its own. From Verviers to the French frontier the French mode of construction is followed. Between Brussels and Antwerp, and in the direction of Holland, the posts and insulators are the same as on the English lines.

THE AUSTRIAN LINES.

These are described, on good authority, as closely resembling the Prussian lines. In both countries the subterranean system has been extensively tried, but abandoned, owing to the excessively bad quality of the gutta-percha covered wire. *(See next chapter.)*

PIEDMONT.

In this country, which the writer proposes to visit on his return to India, it is stated that some of the telegraphic arrangements are of a highly interesting character. From Arquata to Genoa, the wires have been carried from mountain to mountain, over ravines of vast depth, and are supported on masts distant in some places more than three quarters of a mile apart, while oc-

casionally they pass underground, as the level of the country may require. M. Bonelli is the engineer.*

THE AMERICAN LINES.

These are exclusively overground, even in the largest cities, where the wires are carried over the houses. The first line was constructed in 1844. There are now over 18,000 miles in full work. There are two distinct lines between Philadelphia and New Orleans, about 2,000 miles distant On most lines a single wire is used. Lofty pine spars are employed, with *glass* bell-shaped insulators, of the same form as those figured under the head of Baden. In dry weather, and during frost, the American lines convey signals through distances of 700 to 800 miles. But the most recent writers state positively that, in rainy or foggy weather, "*no reliance can be placed on any line in the country.*" To the use of *glass* insulators this failure is ascribed, as these are stated to condense and attract moisture more than any other insulating substance. The writer we quote from recommends the trial of shell-lac and wooden brackets.†

We shall have to revert frequently to the American lines in the sequel of this manual. The interruptions there experienced are chiefly from tornadoes, thunder-storms, and the falling of lofty trees—casualties very likely to visit our Indian lines also. At present, in America, each company employs men to guard their lines. In the populous districts of the north, one guard is stationed at every forty or fifty miles. In the dense southern forests the guards are stationed at intervals of every twenty miles, and their duty is to examine the lines incessantly, especially after storms.‡

In concluding this notice of the Indian and other overground lines, it is desirable to state in detail the facts and reasons which have led to the selection of the heavy rods of 1,120 lbs. per mile, instead of the wires employed in other countries.

* *British Almanac*, 1853, art. "Electric Telegraph," p. 41.

† *American Telegraph Magazine*, New York, No. 3, 15th December, 1852, page 123.

‡ Jones. "Historical Sketch of the Electric Telegraph, New York, 1852," page 95.

In the lines constructed by the writer in the vicinity of Calcutta in 1838-39, with ordinary wire, it was found that fractures were incessantly caused by violent storms, by lightning, by swarms of birds, and by monkeys—by rusting—and by mischievous persons.

In 1850, when orders were given to construct a line to Diamond Harbour, partly subterranean, partly overground, no wire was procurable, but there was an abundance of rod iron of ⅜-inch available in the Calcutta market. Being in lengths of only 13 feet 6 inches, difficulty was experienced in welding it up; still the line was rapidly erected, and 80 miles of such material are now in operation. These lines have withstood the terrible hurricanes of the 24th October, 1851, and the 14th May, 1852, without a single fracture. Swarms of birds occupy them without damage. If blown down, cattle, carts, buffaloes, and even elephants, pass over them without injury. Monkeys, described in the latest official reports, as being almost as large as Bengalees, swarm on the lines near Kedgeree. The rods cannot be broken or cut without the use of smiths' tools. Rusting causes but inappreciable harm. Owing to the great mass of metal, the rods present so little resistance to the electric current, that no insulators whatever are required on the present lines, through which we work without interruption during tropical deluges of rain, with batteries of from two to six elements of platinum wire. In point of expense, the rods now adopted cost on our present contract but £7 per mile, and we obtain them now in lengths of ¼-mile, so that the difficulty of welding is obviated. All these facts are on official record in the reports of the several officers employed on the Bengal lines. An extract from that by Mr. Siddons, dated Calcutta, the 2nd June, 1852, well illustrates the subject:

"The telegraph is going on as well as I could hope for under circumstances which have occurred since your departure.

"On the night of the 14th May, Calcutta and its vicinity was swept by one of those devastating hurricanes which visit India once in fifty years. I must refer you to the newspaper files, which I suppose to be easily procurable in any of the large towns in England, for particulars regarding this cyclone. I may, however, as well mention that we look upon this hurricane as the most furious ever remembered in Calcutta. The

wind fairly screamed for eight or nine hours, and shook the very firmest of our pucka buildings. To give you some idea of the force of the wind, the chief magistrate has officially reported the fall of forty-four pucka houses, some thousands of huts, and the destruction of an immense number of trees of the largest and stateliest kind. The conservancy department carted away 40,000 birds the following morning, consisting principally of kites and crows, and these only from the collection made from the compounds of private houses. In addition to these accidents, I regret to add that the loss of human life has been great both on shore and afloat. The shipping suffered severely at the sand heads, and there is scarcely a pinnace, bauleah, or dingee remaining at Calcutta; the fine boat we had from Dr. Chapman for our guard boat some months ago is among the things that were.

"Now to return to the hurricane. The wind upset several of the bamboos between the place where the iron rod springs from the underground line and Bishtapore. It also destroyed many of the bamboos at this place, laid in ruins the station-house at Bishtapore, and blew down a part of the line between Bishtapore and Moyapore. The lads at Bishtapore did good service; for, when they found their station gone, they joined the Diamond Harbour line on to Calcutta, which allowed us, *without more than half-an-hour's interruption*, to keep up the communication; and as the Kedgeree line was in full work also, we did our work well, and reported all the disasters with great promptitude, which had occurred outside. For three days our office presented a curious scene (*i.e.* the outside of the office): the street was crowded with carriages, buggies, and every description of vehicle, with parties anxiously awaiting our bulletins, which were placarded as the news was received."

If we contrast the above report with the statements published in the English papers regarding the damage to the English telegraph lines during the storm of the 26th December, 1852, and compare the Calcutta interruption of half-an-hour at midnight with the total cessation of work for days on many of the English lines, we find ample reason to conclude that the thick rod system is the only one which affords a chance of establishing *overground* lines of electric telegraph in India.

NOTE.—In page 44 it has been omitted to state that the double wrench handle of the straining apparatus can only be used while the wires are braced for the first journey. After that a single lever wrench must be employed, to prevent its being stopped by the wires.

PART III.

CONSTRUCTION OF SUBTERRANEAN LINES.

BEFORE we enter upon the exact and practical details of the various steps to be followed in the construction of that part of the Indian line which is to run underground, it is necessary to give a sketch of the history of the subterranean system.

In perusing the published accounts of the progress of the electric telegraph, we find that nearly every one whose name is associated with its advancement has attempted to employ the subterranean in preference to the overground method.

In 1809, the illustrious physiologist Soemmering proposed the construction of an electric telegraph, consisting of 35 conducting wires, each to effect chemical decomposition, and to be laid in glass or earthen pipes, each wire insulated with silk.

In 1816, Mr. Ronalds, of Hammersmith, constructed a telegraph line, partly subterranean, the wires in the earth being enclosed in glass tubes, surrounded by a wooden trough filled with pitch. He proposed the tubes to be buried six feet deep.

M. Trebouillet, in 1828, proposed an electric telegraph to be worked by a single wire covered with shell-lac, then coated in silk, and afterwards with resin. This insulated wire was then to be buried in the earth, in glass tubes, carefully luted and joined, so as to be water-tight.*

In May, 1837, Mr. Cooke took out a patent for an electric telegraph, the wires of which were laid in iron pipes. This was constructed on the London and Blackwall Railway, and was subsequently tried, with slight success, on some short lines elsewhere.

In April, 1839, the author, in a paper published in the "Journal of the Asiatic Society," proposed a subterranean line for India, to be constructed of wire, coated with pitch and cloth, and buried in a trench two feet deep, along the common road.

* *The Electric Telegraph.* By Edward Highton, C.E. p. 57.

In 1842, Professor Jacobi constructed a subterranean line from St. Petersburgh to Tsarskoésoélo; the wires were coated with Indian-rubber, and further encased in glass tubes.*

In December, 1843, Morse laid a line of ten miles underground, in leaden pipes, on the road between Baltimore and Washington.

Although, in all the attempts above referred to, the results were unsuccessful, through failure of insulation—and although the overground system introduced by the writer in 1839, and subsequently patented by Mr. Cooke, in 1842, became universally adopted in Europe and America—nevertheless, the many obvious advantages of a *good* subterranean system induced many telegraph engineers to continue their attempts in this direction.

The discovery of gutta-percha, by Dr. Montgomerie, of Singapore, in 1843, has supplied the material by the use of which the object so long sought is now successfully accomplished. It would be tedious and profitless to describe the several stages of alternating failure and success in the efforts to use this invaluable substance as an insulator for subterranean lines. The most remarkable trial was that by M. Siemens, an eminent engineer in the Prussian service, under whose directions some hundred miles of wire, coated with gutta-percha, were laid down in Prussia, in 1849 and 1850. The gutta-percha used was, however, incorporated with sulphur, and this mixture proved fatal to the undertaking. The lines failed altogether, and are now being replaced by others on the overground system. The gutta-percha covered wire accordingly fell into general disrepute, from which it probably would never have been rescued, but for the perseverance and skill of Mr. Statham, the manager of the Gutta-percha Company's works in London. By close and patient study of the material, and by excluding all admixtures of other substances, Mr. Statham succeeded at length in producing coated wire, the excellence of which has been conclusively demonstrated by the perfect success of the submarine telegraph line now in operation between Dover and Calais.

* "Le placement des fils conducteurs dans l'air n'est qu'un pis aller; leur installation sous terre est le seul moyen parfait; mais je considere comme une des fatalités de ma vie, la necessité où je me suis trouvé de m'occuper de cet épineux probleme."—*Letter from M. Jacobi to M. Breguet, quoted in De Moigno's Treatise, 2nd edit., p.* 294.

The introduction of wire coated in this perfect manner is effecting a great change in the construction of telegraph lines. But the high price of the article, and the heavy collateral expenses attending its employment, prevent, at present, its universal adoption. For the Indian double line, the overground method is found less costly than the subterranean, in the proportion of 34 to 60, amounting to a difference of £78,000 in favour of the overground line, on the scale and to the extent sanctioned by Government.

Costly though it be, according to the present rates of manufacture, there are certain localities in which the gutta-percha covered wire must be employed, especially in India.

In the great cities, such as Agra and Delhi, it would be found exceedingly objectionable, with reference to the habits of the native community, to attempt to lead the lines above the houses, as in Paris, or even in their close proximity, as in the American cities. And in many great thoroughfares, where elephants and camels pass in considerable numbers, it would be impossible to protect telegraph posts from dangerous collisions.

The gutta-percha coated wire has been accordingly adopted for use on the Indian lines to the extent of about 700 miles of single line. We have, therefore, to study in detail the properties of this remarkable substance.

Properties of Gutta-Percha.

Gutta-percha is the milky juice of a large tree, the *Isonandra Gutta*, extracted by incisions in the tree, and dried before the sun, or by evaporation at natural temperatures. Little care being observed in the process, the gutta-percha is much mixed with particles of bark, shreds of leaves, and other impurities, and is delivered in commerce in blocks of an irregularly square shape, and various sizes, of a yellowish brown colour, and containing from 10 to 25 per 100 of moisture. Heated to 280°, it melts, or rather softens, to the consistence of treacle. At 140° it is still soft, but very tenacious and adhesive, and kneads together into a consistent uniform mass. At as low a temperature as the

freezing point it continues flexible, and free from brittleness, or tendency to cracking. When purified, it is totally insoluble in water or spirit of wine. It is not acted upon by acids, alkalies, or saline solutions, and is insoluble in fixed oil. It does not unite with melted wax, suet, resin, or pitch. It is very ductile when soft, but not elastic.

In chemical composition, gutta-percha is nearly the same as caoutchouc, or Indian-rubber.

Like caoutchouc, it is dissolved by sulphuric ether, by the liquid hydro-carbons, chloroform, and rectified oil of turpentine, from all of which solutions it is recoverable in its original state; but gutta-percha thus dissolved and recovered becomes whitish and brittle after a short time, and ceases to be applicable for the numerous purposes which, when prepared as subsequently described, it is so perfectly adapted.

When freed from impurities, by the process of manufacture afterwards detailed, gutta-percha has been proved to remain totally unaltered in fresh water for four years; in salt water, for more than two years; in wet earth, for five years. These facts denote the great probability of its continuing unchanged in the same media for an indefinite period.

Of all substances yet subjected to experiment, gutta-percha proves to be the best insulator or non-conductor of electricity. Caoutchouc and shell-lac approach it nearest in this most valuable property. Asphaltum, pitch, and the resins, are far inferior to gutta-percha in insulating power.

As far as experiment has yet been carried, it is not attacked by white ants or other rodent insects, but, like all tasteless substances of its consistence, it is liable to be gnawed by rats and mice.

Gutta-percha is collected in various localities in the Malayan Archipelago, in Borneo, and all the adjacent islands. Singapore is the mart from which it is exported to Europe, and the quantity exported now amounts to 4,000,000lbs. annually. Its price, delivered in London, during the last year, ranged from £3 19s. 4d. to £4 4s. 0d. per hundred-weight. It is free from duty.

Manufacture.

The first object is to free the crude gutta-percha from the impurities above described. This is done by cutting the blocks into thin slices by a heavy wheel of cast iron armed with blades, like those on a carpenter's plane. The wheel revolves with great velocity by steam power. The blocks fall on the knife edges from an inclined shelf, and the shavings are carried through openings in the wheel.

The slices and shavings are next placed in warm water in an iron cylinder, within which a shaft revolves armed with numerous knives, which cut and tear it into shreds. Most of the impurities are thus separated, and fall to the bottom of the cylinder.

The shreds are now boiled in an iron trough, heated by steam, and are thence removed and dried. In this state they are compressed by a piston in a hot iron cylinder, through numerous layers of wire gauze, and are thus filtered from all remaining impurities.

The gutta-percha is now kneaded in cast-iron closed boxes, by massive fluted rollers, kept hot by steam, which thoroughly incorporates the mass, and expels all adhering moisture. When it ceases to emit vapor, it is removed from the boxes in a chocolate-coloured, ductile, wax-like mass, and is now fit to be applied as a coating on wire, to be rolled into sheets, which may be made as fine as tissue paper, and to be compressed into objects of infinite variety of form.

Covering of Copper Wire.

The wire used is No. 16 of the Birmingham gauge. One English mile of 1760 yards, weighs 60 to 63 pounds avoirdupois.

The wires being mounted on a reel, one end is made to pass through a brass or steel conical die or guide, centered exactly in a brass box. A brass or steel tube of conical shape, encloses this die, leaving an interval of the thickness of the gutta percha coating. Through this interval the gutta percha is squeezed from a brass box, opening into a cast-iron cylinder heated by a

steam jacket, by a screw impelled by steam power. The wire is at the same time drawn through by a workman, who winds it up in the covered state on a reel placed at the opposite end of a long trough of water kept at the ordinary temperature of the air. and through which the coated wire is delivered.

The wire thus obtains successively two coats of gutta-percha, and these are applied of different thickness, according to the object for which the wire is required.

That adopted for use on the Indian lines is No. 3, double coated. The weight of gutta-percha on an English mile is 110 pounds. The thickness of the double coat is $\frac{3}{16}$ inch. The diameter of the coated wire is $\frac{1}{4}$ inch. Its price on the present contract is £17 10s. per mile. Wire included, one mile, 1760 yards, weighs 176 pounds = 10 yards per pound.

The wire thus prepared, at temperatures varying from the freezing point to 130°, is free from adhesiveness, so that when coiled up it is not liable to the turns sticking to each other. It may be bent to an angle, however sharply or suddenly, without cracking. Exposed to the sun's rays it softens rapidly. At low temperatures it is still so soft that it may be cut through by the pressure of the nail.

Joints.

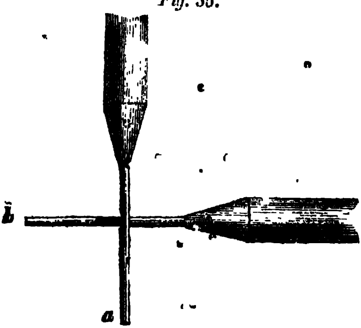
In preparing a continuous line of coated wire the *joints* require the most minute attention.

The wire itself has to be united metal to metal. The coating has to be joined in a perfectly continuous mass of gutta-percha.

The gutta-percha is first stripped off from the ends of the wires, which are to be joined together, to the extent of about 4 or 5 inches. The copper ends are then well cleaned with sand-paper, to make the solder adhere. The wires are now placed so as to cross each other at right angles at the middle part of each copper end, leaving 2 inches of wire free. A man now holds the wires, where they cross, firmly with a pliers; another man takes hold of the free end of the wire (*a*) turned towards him with his fingers, and seizes the end of the other wire (on his right hand side) with a pliers; he then twists both ends round each other

in a slanting direction and evenly, for three turns, taking care to keep the ends of the wires, as he turns them, at the same angle.

Fig. 35.



He next nips off the ends of the wires quite close, and files them down, until no sharp point projects upwards; after which he dresses the joint straight with gentle taps of a small hammer.

The joint is now gently heated over a spirit-lamp, and moistened with a solution of the chloride of zinc to make the solder unite. This done, the joint is touched lightly with a stick of bismuth solder, until

Fig. 36.

it looks as if it were tinned over. If too much of the solder has been applied the joint may be gently warmed over the spirit-lamp, and the superfluous solder picked off with the end of a wire.

Fig. 37.

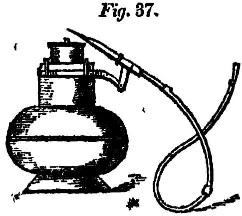


Fig. 38.

While the wire is still warm, the ends of the gutta-percha should be pointed off conically by pressure of the fingers along the wires, which will assist the after work. When the joint has been soldered, the man takes a strip of gutta-percha

leaf about $\frac{3}{8}$ inch broad, and having gently warmed over the spirit-lamp the joint and bare wire, he immediately applies one end of the strip on the pointed end of the gutta-percha, and winds it round the wire and joint to the pointed end on the other side. Each turn should overlap the other about one-half. This first covering must be pressed well on until it gets cool; after which its surface is *very gently* warmed over the lamp, and a second strip of leaf is applied, in a direction the reverse of the first one. When this has cooled, a third slip of the leaf is wound round as before. A piece of $\frac{1}{8}$ inch thick gutta percha is next taken, made soft by warming, and then placed so that the parts covered by the strip shall run along its middle. The two sides of this piece are then pressed upwards with the fore-finger and thumb in a gradual manner, so as to make the piece adhere firmly to the coils of the leaf, and also to the pointed part of the original gutta-percha, which must be heated so as to ensure perfect adhesion.

The superfluous parts are next cut off with a scissors; a blunt steel blade is heated over the lamp, and with it the joints of the last portion of gutta-percha are worked up together, until no trace of a fissure or joining can be seen anywhere. The tools must not be heated too much, to avoid burning the gutta-percha, and the workmen's hands must be free from any dirt, oil, or grease, which would prevent the surfaces of gutta-percha from uniting together.

Fig. 39.

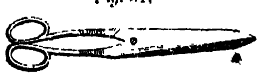


Fig. 40.

The tools employed in making these joints are supplied to each working party in a chest, containing a spirit-lamp and wood naphtha, which is the best source of heat for this purpose;* a blow-pipe is attached to the spirit-lamp, and is found very useful in directing the flame of the lamp on the wire joint while soldering. Blunt pliers for bending the wires; a blunt blade for pressing the warmed gutta-percha to a smooth surface; scissors

* Spirit of wine may be used, but oil must never be employed.

and pointed wires, are also included. A stock of gutta-percha leaf and sheet, sufficient for 150 joints, is given with each chest (*See invoice list of contents of tool-chest, given in Appendix*).

Where the gutta-percha wire is coated with lead, as is subsequently described, the joining of the wires is effected in a different way, which will be pointed out as we proceed.

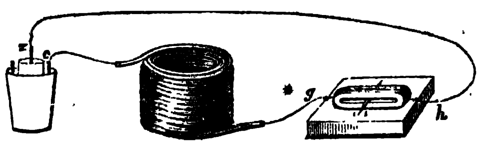
Testing Coated Wire.

Before any wire is made use of on the lines, it must be *tested* on the spot to ascertain—

1. If the metal be continuous.
2. If the coating afford perfect insulation.

The test for the first is passing the current from one element of Daniel's battery through the wire placed in circuit with the zinc galvanometer described at page 7. The ends of the coil of wire are freed from gutta-percha for one inch; one end is connected with the copper side of the battery, the other end is connected with one terminal of the galvanometer coil; the second terminal of this, *h*, is joined to a wire which may be made to touch the zinc side of the voltaic element at pleasure. Each contact causes the needle of the galvanometer to deviate hard up to the stop.

Fig. 41.



To test the perfect insulation afforded by the coating of gutta-percha, a more difficult process is essential. We shall first describe this as it is actually performed at the gutta-percha works in London, where it has been applied by the writer to all the wire manufactured for the Indian lines.

The battery employed consists of 360 cells (30 sets of 12) of the sand and acid kind.

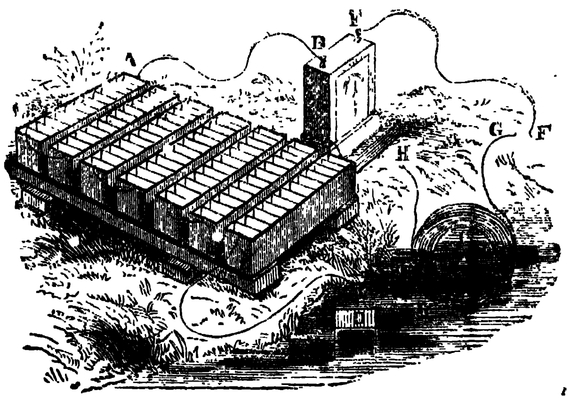
The wire to be tested is submerged for 48 hours in the canal adjacent to the factory.

The metallic ends of the submerged wires are led into the office, and a plate of copper, D, connected with the copper side of the battery, is immersed in the canal.

The zinc side of the battery is connected with one terminal of a galvanometer, B. For this the sine galvanometer described at page 7 may be employed.

The second terminal of the galvanometer, E, is left free, so that it may be touched at pleasure by the operator, holding either end of the coated wire under trial.

Fig. 42.



The ends of the wire to be tested, G, H, are kept out of the water and perfectly dry. If the current of the battery be now passed into the wire from the zinc side, through the galvanometer, it is obvious that the needle will be *permanently* deflected if there be any fault, however slight, in the coating, as the current will pass through the coating to the water, and by the water to the immersed plate D, back to the battery.

In testing 110,000 yards of wire thus prepared, on the 1st of November, 1852, no *permanent* deflection whatever took place

demonstrating the absolutely perfect insulation by the gutta-percha coating.*

"*Charged*" *Lines.*

But it always is observed that the moment contact is made between one end of the wire under trial and the battery, the galvanometer being included, the needle deviates for an instant, and then returns to zero, or the point of no deviation. This is the result of what is termed the *charge* among telegraph operators, the nature of which must be adverted to here in some detail.

The more perfect the insulation is, the more remarkably is this *charge* observed. It is caused by the *inductive* action exercised laterally (as noticed in page 3) on the applied copper conductor, and by this on the water, also an electric conductor, by which the copper wire is surrounded, but which are kept from contact with each other by the insulating coat of gutta-percha.

The wire being rendered, say *positive*, by contact with the zinc side of the battery, the water in its proximity is rendered *negative* by *induction.* The positive electric charge seeking to meet the negative, actually penetrates to a certain though very minute depth into the substance of the gutta-percha coating. Unable to pass through this, it returns to the copper wire under trial, but enough passes as a wave or current, through the galvanometer, when contact is made with the battery, to cause the deviation of the needle for a single beat.

The attentive observer tracing the diagram will see that there is no complete *voltaic circuit* formed. The occurrence is one of charge and discharge in the wire itself. The same takes place in the Leyden bottle, when its inside coating is charged by contact with the prime conductor of a common electrifying machine. In this instance the inner coating of tin-foil is separated from the outer coating by *glass,* as the copper wire is separated from the water or earth by gutta-percha. It is found, too, that the

* The Prussian Government allow a loss of $\frac{1}{30}$th part of the electric current employed in testing for each mile of wire. With this laxity in testing it is not surprising that their subterranean lines should have failed altogether.

charge penetrates more deeply into glass than into the gutta-percha. Glass accordingly retains the charge longer, and parts with it more slowly. With a gutta-percha coating the discharge or recoil is instantaneous and complete. If the wire were coated with glass, and this immersed in water, the discharge would be gradual, and would accordingly interfere seriously with the transmission of telegraphic signals.

This fact of *charge* and *discharge* is noticed very remarkably in working the subterranean line, which extends from Calcutta to Bishtapore, about 12 miles, along the Diamond Harbour road. In perfectly dry weather it is not observed, but when the earth is wet, in the rainy season, a single contact of the line with the battery at Calcutta charges the line, so that when the Calcutta telegraph is turned on to the line (as in receiving an answer from Diamond Harbour) the *charge* causes the needle to deviate in the same direction as if a strong signal beat had come from the opposite or Diamond Harbour end of the circuit.

If several contacts be made in the same order, that is, so as to render the line, say 3 or 4 times positive in succession, as occurs in signalling letter D, by four beats at one side, thus :—

/ / / /

it is found in wet weather that the return discharge is so strong, that it is necessary in the *last* letter of the *last* word signalled to give one opposite and supernumerary beat, somewhat prolonged, in the contrary, say negative, direction, thus :—

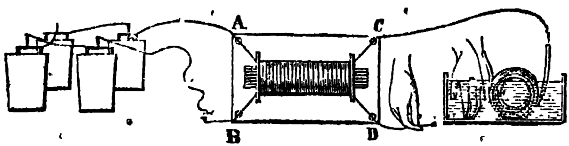
/ / / / \

to neutralize the positive state of the line. With this precaution, which the signallers very soon learn the necessity of, the answering signals are received without the least confusion.

The line referred to is insulated by a triple coating of Madras cloth, impregnated with pitch, and is further encased in a melted cement of sand and rosin, averaging one inch in thickness. Its taking the *charge* is the best proof of its good insulation; but the slowness with which the *discharge* takes place denotes a facility of penetrability which would cause the application of this system of insulation to fail on very long lines.

As the testing of the wires is best accomplished by a current of the great intensity produced by a vast number of couples, the sand and acid battery is the best for the purpose; but it is manifestly impracticable to provide such a cumbrous apparatus at every station where a piece of coated line may be under trial. With the following simple apparatus, however, a current of sufficient intensity may be generated by three or four of Daniel's cells, to test the wire as certainly as by the series of 360 couples.

Fig. 43.



Around a hollow cylinder of wood, 1 inch in diameter and 4 inches long, wind a spiral of silk-covered copper wire, $\frac{1}{20}$th inch in diameter, and let this winding continue till four layers, or 50 to 60 feet of the thick wire are wound on. Let the terminals be connected with two screws, *a* and *b*. On the same bobbin, and in the same direction, wind 200 yards of the finest copper wire, covered with silk, say $\frac{1}{100}$ to $\frac{1}{128}$ inch diameter. The terminals of this wire are to be connected separately with two screws, *c* and *d*.

Within the wooden core place a bundle of common iron wire, each wire coated with sealing wax. The apparatus is now complete.

Now let *a* be joined with one end of a battery of four of Daniel's elements, and *b* be made to touch the opposite side of the battery, contact being made and broken at pleasure. It is found that every time contact is made or broken an induced current of electricity of enormous intensity flows in the fine wire, the terminals of which, *c* and *d*, may be used accordingly, instead of the poles of the battery of 360 couples, employed in the experiments above described. It is to be noted carefully that the induced current takes place either by contact or by breaking contact; but if the current of contact is positive, the

current of rupture is negative, and if rapidly passed in succession, these opposite currents would neutralize each other in the effect on the galvanometer. A steady contact, followed by rupture, each lasting one second, exhibits the effects on the galvanometer, without confusion of the movements of the needle in opposite directions. But these movements are readily confounded with the effects of "*charge*," already described. A better test with this instrument is the *shock* experienced by placing one hand in the water in which the coil under trial is immersed, and the other hand in contact with one of the fine wire terminals, the second being joined to one end of the wire under trial. The slightest defect of insulation is detected by a sharp shock transmitted through the coating and the water, through the observer's person, whenever contact is made or broken between the thick wire terminal, *t*, and the battery.

MECHANICAL PROTECTION OF COATED WIRE.

From the detailed account given of the properties of gutta-percha, it is evident that a coated wire, buried in the earth, must be exposed to many causes of injury, unless protected by some strong resisting envelope.

The pressure of a sharp pebble, or of a fragment of brick or pottery, the gnawing of rats and mice, the friction of rough sand moved by the pressure of cart wheels, all these causes have proved in practice sufficient to injure the gutta-percha coating and expose the wire.

The obvious difficulty and delay which must occur in detecting the exact place of injury on an extensive line, buried in the earth, and the expense of opening and refilling the trench, are additional and strong reasons for giving the coated wire, in the first laying down, such efficient mechanical protection as may be practicable within the limit of outlay prescribed for the work.

Restricting our observations at present to *subterranean* lines, and reserving the consideration of those which are to be led under rivers or the sea, we find very numerous plans proposed

or carried into effect for the protection of the wire. We shall first describe those actually adopted, and subsequently those proposed, but not yet subjected to trial on a large scale.

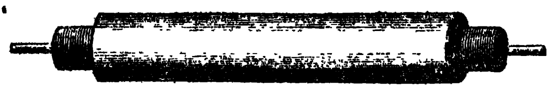
Leaden Tubes.

After many failures in attempting to coat the gutta-percha covered wire with lead, Mr. Chatterton has succeeded, and has patented a process by which the coating of lead is applied on the gutta-percha *cold*. 300 miles of this wire have been lately placed underground by the Danish Government.

128 miles of wire thus protected have been ordered from Mr. Chatterton, chiefly for use in the great cities on the lines, such as Calcutta, Agra, Delhi, Bombay, and Madras, in which the wire will be buried at a depth of three feet, in order to avoid as much as possible the interruptions and inconvenience of frequent openings of the ground in such crowded thoroughfares.

The leading is marked 3 B in Mr. Chatterton's scale. The weight of lead is 13 cwt. 3 qrs. per mile; cost of leading, £17 per mile; thickness of lead, $\frac{1}{8}$ inch; diameter of coated wire, leading included, $\frac{3}{8}$ inch.

Fig. 44.



The article is delivered coiled in drums, each containing 500 yards; weight, drum included, 486 lbs. The reels are about 1 foot thick, 19 inches in diameter. At this curve the line [illegible]y, and without injury, the drum being mounted on a temporary axle, with bearings and a supporting frame. As the coils are but 500 yards in length, each mile of this line will require three joints to be made, both in the gutta-percha and the lead tubing. This operation is a very delicate and critical one, and should in all cases be performed under the eye of the principal superintendent at each place.

The joint in the copper wire is not a twisted one, as before

described, as this would prevent the leaden tube to be subsequently used from passing over the joint.

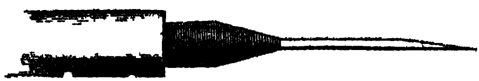
The joint is thus made :—

1. With a sharp and strong penknife blade, and by a circular cut, cut through the *lead* transversely, and strip this off two inches from the end of the tube, taking care not to touch the gutta-percha.

2. Heat the gutta-percha end gently over the lamp, and remove the coating by the finger and thumb to within half an inch of the lead.

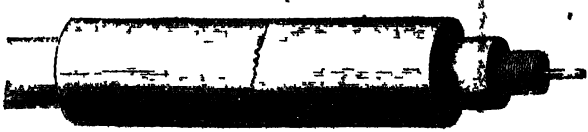
3. Clean the copper wire with sand-paper, and with a fine flat file reduce one end to the shape shown in the cut

Fig 45.



4. Over the end of *one* of the lines slide the joining tube, shewn in the cut. These are supplied of such diameter that they pass smoothly over the leaden coating. They are 5 inches long, and an abundant supply accompanies each case.*

Fig 46.



5. The free copper ends of the wires are now to be joined with common solder, by means of the blow-pipe, chloride of zinc, and soldering tools previously described (*Fig.* –, –).

6. A very fine copper wire is wound in one close spiral round the soldered ends, for the length of one inch, and touched with solder over the lamp. In this step the utmost care must be taken not to burn the gutta-percha at either side (*Fig.* 47 *b*).

7. The wire joint is now to be coated with three turns of

* The break line in the cut serves to show that this is shorter than the actual tube itself.

gutta-percha leaf, and one fold of gutta-percha sheet, till the coating be brought uniformly and smoothly to the same gauge, exactly as the rest of the line. *(See dotted line, Fig. 48).*

Fig. 47 a.

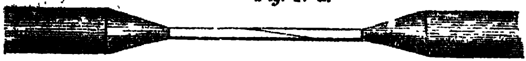
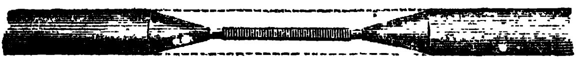


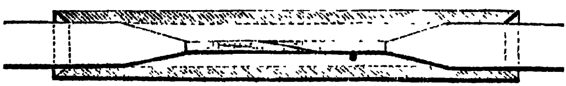
Fig 47 b.

Fig. 48.



8. The sliding tube is now moved over the new joint, which should be in its centre. When in its place, an expert workman, with the point of a pen-knife, removes a shred of the lead from the inner edge of the tube all round (*Fig. 49*).

Fig. 49.



9. A soldering tool of stout iron wire is now heated gently over the lamp, and with this, and a fine rod of fusible metal, a slight film or ring of this metal is run into the bevelled edge of the sliding tube, which is thus permanently soldered in its place.

The fusible metal is composed of pure tin, 2 oz., bismuth, 4 oz., pure lead, 1½ oz., melted together, and run into thin rods. The bismuth is melted first, the tin then added, and the lead last.

The harder or common solder used for the ordinary joint is composed of equal parts of tin and lead.

Testing the Lead Joint.

This is to determine whether there be any metallic contact between the lead coating and the copper wire, which would spoil the whole line.

For a short line, say of two miles, it is sufficient to use two or three of Daniel's cells. Attach the copper end by a wire to the end of the prepared copper wire, about an inch of which is left free for the experiment. Round the lead tube twist a turn or two of wire, and join this to one terminal of the galvanometer. Now touch the other terminal of the galvanometer by a wire from the zinc side of the battery. If there be contact between the coated wire and the lead tubing, the needle will be permanently deflected, and the failure of the line is proved.

In this case the joints must be reopened, and made anew, till the galvanometer is not affected, and the leaden envelope thus proved to be completely insulated from the line wire.

Sixty Europeans have been trained at Warley to the manipulations above described. But the superintendent of each circle is bound to have these joints made and tested in his own presence.

Duration of Leaden Tubing Underground.

The duration of the leaden tubing underground depends much on the nature of the saline matter with which the ground is impregnated. The presence of sulphate of potash or soda in the ground retards almost indefinitely the corrosion of the lead, which in sea-water, rain water, or a soil containing nitre or alkaline carbonates, would undergo very rapid disintegration.

As the soil in Bengal usually contains an abundance of the protecting sulphate of soda, there is but slight reason to apprehend the corrosion of the lead. But in all cases the tube should be finally wound with a spiral envelope of Madras cloth, two inches wide, saturated with pitch, softened by Stockholm tar. The spirals should overlap one-half.

The tube is now ready to be laid in the trench, which for the leaded line should be at least three feet deep. The earth, as refilled, should be moistened with water, and beaten into the trench at every six inches by heavy rammers.

LINES LAID IN SAND AND ROSIN.

At page 69 we have already noticed the subterranean line, 12 miles in length, from Calcutta to Bishtapore, which, partly for

experiment, partly from the want of other material, has been constructed in a peculiar manner, which should be described in detail.

For these twelve miles the line is made of round rod iron, ⅜ inch diameter, made up from separate lengths of 13 feet 6 inches each, welded together end to end. This was first done at the iron bridge works at Alipore, so as to form lengths of 200 feet. These, in bundles of ten rods, were carried on men's shoulders along the road, laid end to end and welded up by a party of native blacksmiths, with a portable forge, in charge of a European sergeant. A mile daily was thus done with ease.

The rod being supported on bamboo stakes, 3 feet above the ground, was next coated with two layers of Madras cloth, saturated with melted pitch, softened with a due admixture of tar, so as to form a flexible coating when cool. These coatings were applied in spiral bands, each 2½ inches wide, wound round like a surgeon's bandage, and overlapping each other in opposite directions, so as to give four layers of a pliable insulating envelope, quite impervious to water and saline matters, not liable to decay or to the attacks of white ants or vermin of any kind.

This coating was applied by a native *tindal* (boatswain), with twenty *lascars* (sailors), at the rate of 2,000 feet daily.

To protect the rod still further, chiefly from mechanical injury, it was finally laid in a row of thin roofing tiles, of semi-cylindrical form (the *koprile*, of Bengal). These were *half* filled with a melted mixture of three parts dry sand and one part rosin by weight, and, when laid, the whole was filled up with the same melted mixture. When cold, the mass is as hard as brick or sandstone, and perfectly impermeable to water when well prepared.

The sand used for this process must be *sifted* to free it from particles of straw, leaves, and sticks; next thoroughly *washed*, to remove clay and saline matter; thirdly, *dried* perfectly, over a furnace of iron plates, heated by a strong fire When quite dry and cool, it is stored in barrels for use.

The rosin and sand, weighed in separate bags of 10 lbs. rosin, and 30 lbs. sand, are sent on the road, and melted in iron bowls (*kurrays*), on temporary fire-places by the roadside. The mixture is thoroughly incorporated during the melting of the rosin, and

poured on the tiles from iron ladles with long handles. This part of the work demands the closest attention. If carelessly done, the mass is as porous as a sponge. It is tedious accordingly, and required 50 men, under a European sergeant, to lay down 1,500 feet daily.

On cooling, the surface frequently shows air-holes left by the expulsion of gas through the melted mass. These holes are sealed up by a little of the same cement before the trench is refilled.

As stated at page 69, the insulation of this line is excellent, and its mechanical solidity perfect; but its retention of the *electric charge*, described in the same page, renders it inapplicable to the construction of long lines. For short special lines —say of ten miles—unconnected with any long circuits, the plan presents several advantages — not the least of which is the facility with which all the materials are procurable in most of the native bazaars.

IRON PROTECTORS.

Many forms of iron protectors have been used. We proceed, as before, to describe those at present employed on a large scale

Gas Pipes.

The old Electric Telegraph Company are at present laying additional lines through the streets of London and the New-road, in gas-pipes three inches in diameter.

The trench being opened, the pipes are laid for distances of 100 to 150 feet. An iron wire, No. 8, with a loop at each end, is threaded through the pipe, the ends protruding, and the earth is then filled in at once.

At every 100 or 150 feet the pipes are separated by an interval of four feet, where the trench remains open.

The gutta-percha covered wire, coated with tape and pitch, in bunches of parallel strands, and in lengths of about 180 feet, is drawn through each length of pipes by the iron wire previously inserted, and to which a rope is secured.

When two lengths are thus drawn into the tube, the ends of

the gutta-percha wires are joined, and the joints coated in the manner described in page 65.

An iron box, in two parallel pieces, is now placed in the trench, so as to protect the joints thus formed. Wooden boxes are often used instead of iron.

Wrought Iron Tubes.

These are procurable from half-an-inch to two inches in diameter, four to twelve feet long, with screw joints. A ¾-inch tube will receive three gutta-percha lines, *not* taped. An inch tube will take four lines, taped and pitched. The lines are drawn through the tubes in the manner above described. The present price of 1-inch pipes, according to Messrs. Jones's circular, is 7d. per foot, with a discount of 25 per 100 on large dealings and cash payments. Per mile, £154.

Flanged Iron Tubes.

These are formed of two semi-cylinders, with flanged edges. One piece is laid in the trench like a trough, the gutta-percha wires placed in position, and the upper side placed over and screwed on. This is a very effective mode of protection. It avoids the risk of injury to the wires in drawing through closed pipes. It enables the wires to be laid with facility in lengths of half-a-mile, or even a mile, without a new joint being required. But these pipes are very costly, bearing a patent or "royalty" price in addition to that of the metal.

Cast Iron Troughs.

These troughs are shown in *Fig.* 50. They consist of an open trough, 6 ft. long, 1½ inches square, with a socket end, and provided with a lid of corresponding size. They weigh 40 pounds to 2 yards, and receive 12 wires. A patent has, strange

to say, been taken for this form of trough, and th s elevates its price to 1s. 5d. per yard, £124 13s. 4d. per mile. It has been used through London by the Submarine Company, from their office in Cornhill, over London Bridge, the commencement of their Dover subterranean line. It is also employed by the company working Mr. Henley's patents for the London street works, leading to their subterranean lines now in progress to Manchester and Liverpool. Three years ago, similar troughs were cast for the Indian lines at the Cossipore gun-foundry, and drawings are filed in the Calcutta Telegraph Office. We shall accordingly employ them extensively, making our castings in the country, when the price of iron falls to a natural state. They will be found particularly useful at street crossings, for small bridges, culverts, and arched drains, in the course of subterranean lines.

The Writer's Iron Guards.

These guards are shown in the cuts, *Figs.* 51, 52, and are applicable to subterranean and also to many river lines.

Fig. 51.

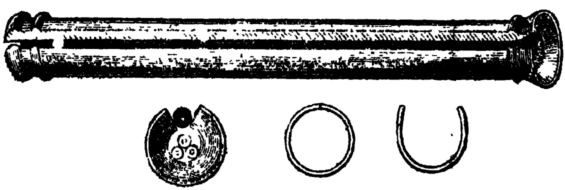


Fig. 52.

Each piece is a hollow cylinder, 1 foot long, 1¼ inch in diameter, ¼ inch thick, open longitudinally by a bevelled cut, 7/16 inch wide externally, ¼ inch internally; diameter of hollow cylinder internally, ¾ inch. One end is concave, the other con-

vex, so that, placed in series, they fit ball-and-socket fashion. Each end enlarges to 1½ inch diameter, and is grooved transversely to receive binding iron loops.

These tubes being laid in series along the trench or *dry* bed of the river to be crossed, a few parallel strands of tarred yarn are introduced into the cylinder, through the side opening, and pressed in firm with a piece of hard wood. The gutta-percha wires are then laid in, and covered with a second layer of tarred yarn, also pressed in strongly with the wooden wedge.

An iron ½-inch rod is now dropped in and along the opening, which it fills up securely, but through which it cannot enter so as to press on the gutta-percha wires.

The whole is now secured by two loops of ¼-inch round iron, applied on the transverse grooves on each end of the joint. The loops are slipped on open, and then bent into the circular form required by a powerful pliers.

The flexibility of this jointed guard renders it applicable under many circumstances where a rigid trough could not be used. Many of the roads in India have parallel canals or trenches three or four feet wide, with water enough to permit of their being made use of by canoes impelled by poles, and carrying cargoes of grain or merchandise. The Diamond Harbour road gives a good instance of this kind. In many such places it will be found very convenient to use the guards now described. They can be applied at the side of the trench or canal, lifted up and dropped in without injury to the wires; and they effectually resist any mechanical impact, collision, or friction to which they may be exposed.

In ordinary subterranean work, too, these guards enable us to use a trench only 6 or 8 inches wide, instead of 1½ to 2 feet, a width necessary when men have to go into the trench to lay pipes or troughs.

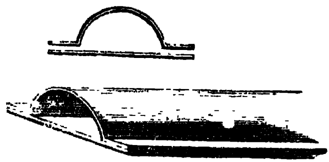
The weight of these iron guards is 2 lbs. 1½ oz. per foot = 99 cwt. per mile, at 8s. per cwt. = £39 12s. to £40 per mile.

Galvanised Wrought Iron.

Messrs. Morewood and Rogers have, at the writer's request, prepared specimens of wrought iron flanged guards and lids, of

which drawings are given. Experiment is required, and will be carried on in Bengal, to determine the durability of this kind of

Fig. 53.

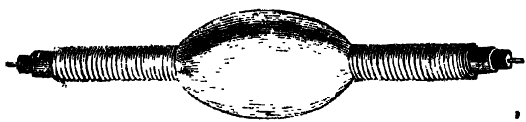


protector in the ground. Should it resist corrosion, this form of guard can be made up with great facility, and at a very moderate price. (*Fig.* 53.)

Wire Spirals.

Some miles of gutta-percha line thus guarded are now under trial in the vicinity of Calcutta. (*Fig.* 54.)

Fig. 54.



The spiral tubes were prepared by coiling No. 8 wire round an iron mandril, ½ inch in diameter. The joints were made by zinc ingots, as shown in the cut. 9 inches of wire, No. 8, were allowed for 1 inch of gutta-percha line. The wire guard thus costs, at present prices, £54 per mile, which restricts the employment of this plan to very few cases. A line thus prepared is as flexible and manageable as an ordinary rope.

Mr. Henley has just taken out a patent for coating gutta-percha wire with spirals of thin galvanised iron wire, exactly similar to those now described.

Iron Ribbon Tubing.

A patent has been recently taken out by Mr. H. V. Physick, for protecting gutta-percha wire with a coating of tinned or gal-

vanised iron, applied by a very ingenious machine, in the same manner as the metal tags on the ends of a stay-lace. The specimens supplied to the writer by Mr. Physick are capable of being coiled in a circle of 4 feet in diameter. It cannot be bent safely at a sharp angle, or coiled into a small circle. Its unrolling is rather difficult. Mr. Physick informs us it is applicable to many places on the overground lines, where perfect insulation, of much mechanical strength, is required. Its moderate price, £10 per mile, recommends it to free trial. For underground lines, if galvanised, or with zinc protectors, it will last for a very long time underground, in any soil impregnated with saline matter. In experiments made by the writer in 1841, under the orders of the Bengal Government, and published in the *Journal of the Asiatic Society* of Bengal, vol. xii., p. 1070, it was found that tinned iron plates were perfectly protected in sea water by much smaller quantities of zinc than were required by equal surfaces of iron plate. In brine somewhat concentrated, tinned iron suffered no damage without zinc protectors; but in perfectly fresh water the tinned plate was corroded although zinc was used.

These facts justify a rather extensive trial of Mr. Physick's patent wire, and 20 miles of the gutta-percha line for Bengal will be prepared accordingly in this manner.

Mr. Physick's apparatus may be used very conveniently for coating short lengths of wire with pure tin, copper, or lead, for many special purposes which will render its use extremely useful in the principal laboratories and workshops of telegraph lines.

EARTHENWARE.

Glazed earthen pipes of the best stoneware, three inches in diameter, are, it is stated, to be employed by the old Telegraph Company, for the subterranean line they are about to run from London to Liverpool. These pipes, cost £60 per mile. The gutta-percha wires must be drawn through them, as described under the head of Iron Pipes.

These glazed stoneware pipes are, in the opinion of the author, far preferable to iron pipes. They afford all the mechanical protection required, and are totally indestructible by corroding agents of any kind.

Mr. Bourne, the manufacturer of the stoneware insulators, has, at the writer's suggestion, prepared glazed stoneware troughs, tubes, and cylinders, with side openings, of all of which cuts are given. Any of these patterns can be supplied by Mr. Bourne, at 1½d. per foot, or £33 per mile. The rectangular pattern is strongly recommended. It will hold six taped wires, and may be efficiently and strongly closed by a layer of Portland cement, or any other hydraulic preparation. This sets rapidly, so as to form an adequate mechanical guard, from which the wires can at any time be detached uninjured by slight blows of a hammer.

Fig. 55.

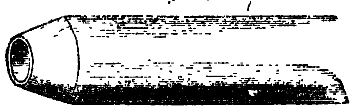


Fig. 56.

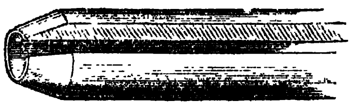
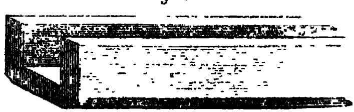


Fig. 57.



Unglazed tubes and troughs of ordinary brick clay, can be prepared on these patterns, in most parts of India, at an exceedingly cheap price. From £10 to £15 a mile will, in most localities meet the cost of any form which may be adopted. The rectangular or tubular shape, open at the side, is to be preferred where hydraulic cements are procurable. The closed tubes, or pipes requiring the wire to be drawn through, are not to be used when the other forms can be procured.

A very simple, cheap, and effective protection is afforded by common tiles of the shape shown in the cut, grooved along the centre, and applied break-joint fashion, with a thin layer of

hydraulic or even common mortar. As the gutta-percha wire is in all cases to have an envelope of either spun-yarn or tape

Fig. 58.

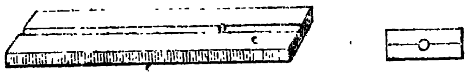
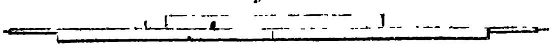


Fig 59.



saturated with tar, the porous and absorbent nature of the tiles or unglazed tubes is no objection to their use. (*Figs.* 58, 59.)

SLATE.

Messrs. Dixon and Co., of the Royal Slate Quarries, in Bangor, have, at the writer's application, made up patterns of slate protectors.

These are 18 inches long, 2½ broad, 1¾ thick, with a groove capable of containing 6 taped gutta-percha wires. The groove is slightly bevelled, so that it can be closed by a slip of wood ⅝ inch thick, and fastened by a peg let through the slate and wood at each end. The wood is creosoted.

These protectors cost £11 per 1,000, delivered at Liverpool, £38 14s. per mile. Their weight is so great—29 pounds per 6 feet = 10½ tons per mile—as to render freight to India and transit in that country prohibitory of their use; but in many localities in England no better protector could be devised.

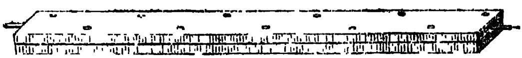
WOODEN PROTECTORS.

In the writer's official Report to the Military Board of Bengal, dated 24th December, 1849, pages 25, 26, 27, it was proposed to lay the subterranean lines in battens of teak, iron-wood, or saul timber, coated with pitch; the timber to be pickled in sulphate of copper or chloride of zinc solution.

This plan is now followed in England on many of the great lines, either finished or in course of construction.

The wooden battens to be used for one or two gutta-percha lines are double (*Fig.* 60), each $2\frac{1}{2}$ inches broad, 1 inch thick, each grooved as shown in the cut, in any lengths to which the timber

Fig. 60.



can be conveniently sawn. Iron-wood, teak, or saul, are to be used where procurable at moderate prices. The iron-wood need not be pickled; all other timber requires that operation; and any common timber, such as pine, or even mango-wood, can be employed, provided the pickling be properly performed.

The sulphate of copper is to be preferred in India as the pickling substance, because it is easily procured or made in all localities. It is very cheap; it is efficient, through its offensive taste, in keeping off rats and mice, as well as ants and other insects. Its preservative properties are proved by long experience on the French lines, and by facts observed in India.

In pickling wooden battens for the Indian subterranean lines, the slips of timber must first undergo perfect drying. In the hot season this is accomplished by exposure to the sun, and better still to the hot winds. In the wet or cold seasons, the battens are to be placed in an oven, and a current of hot air sent through this till such pieces cease to lose weight. *This operation is essential to the success of the pickling.*

The pickle is prepared by dissolving 20 pounds of sulphate of copper in water in each trough. These are procurable from the Arsenal of Fort William, and are 32 feet long by 1 foot section.* The battens are previously arranged in the trough so that they are 1 inch apart from each other, and secured in their places by stone or brick weights. The copper solution is now poured on, and the steeping is continued for two days, or until the testing pieces show that the wood is thoroughly penetrated by the solution.

* These troughs formed part of the stores of the Gold Refinery formerly attached to the Calcutta Mint.

Testing the Wood.

This is done by taking a batten, drying it perfectly, and sawing it across. A few grains should then be bored out of its centre with a gimblet, and placed in a liqueur-glass of warm water, in which a little prussiate of potash has been dissolved. If the timber be effectually penetrated by the solution, its colour changes by the test to a fine chesnut brown.

White arsenic dissolved in water may, under some circumstances, be substituted for sulphate of copper.

Its efficacy in preserving the timber from decay by rot or fungus is unquestionable, but it is doubted by many whether white ants, rats and mice, can be kept off by any tasteless compound.

Wherever arsenic is used, the pickling process is the same as that above described, 5 pounds of arsenic in solution being used for each trough. The test is a drop or two of a solution of nitrate of silver applied to a trial boring, and after the silver test is used the wood is to be touched with the stopper of a bottle containing strong ammonia. The wood immediately assumes a vivid yellow colour if the pickling has been successful.*

The chloride of zinc is believed, on very strong grounds, to be as efficient a preservative as arsenic; but its presence is detected with difficulty, except by an experienced chemist, and its affording protection against rats and mice is exceedingly questionable.

Corrosive sublimate should not be used, as it is now proved not to be depended on even for protection against white ants.

COATING WITH TAPE.

In the lines laid across the Hooghly and Huldee rivers, and several smaller streams in Bengal, the gutta-percha wires have been coated with tape saturated in a composition of wax and

* The tests referred to are included in the medicine chest supplied to each working party.

turpentine, the object being to protect the gutta-percha from the contact of water.

In England, for the same purpose, the subterranean lines are now in most cases coated either with tape saturated in tar, or served with tarred spun-yarn.

Mr. Physick has contrived a simple and effective machine, by means of which one, two, or four gutta-percha wires are coated spirally with tape ⅝ inch broad, and the spirals overlapping one half. The wire, when coated and carefully examined, is wound off the reel through a trough containing *warm* (not *hot*) tar, mixed with a little turpentine and lime. The lime is added to neutralize the acid of the tar. From the tarring-trough the line passes into another trough containing dry sand, through which it passes, taking up a thick coating, which affords an excellent protection against wet, rot, and insects. Whether rats and mice will spare it is not quite certain.

One mile of gutta-percha wire takes three miles of tape at £1 per mile. Mr. Physick performs the taping on contract at £6 per mile.

Two of Mr. Physick's taping-machines are to be supplied to the central workshops, and this process, or that next described, will be applied to the whole of the Indian subterranean lines.

Spun-yarn.—The lines in progress to Liverpool for the Magnetic Telegraph Company are served with tarred yarn, by machines contrived by Mr. Henley. The cost of yarn and serving is about £3 per mile. This plan is not so much recommended as the taping; but when tape is not procurable, it affords a very useful and cheap envelope.

Horsehair Felt.—A coating of this substance has been proposed by Mr. Griffin for the protection of gutta percha wire. It is applied cold in a semi-fluid state, and forced, under great pressure, through dies. It becomes almost as hard as stone, according to Mr. Griffin's statement, still remaining elastic; price about £8 per mile.*

The writer has not seen specimens of this article, and doubts

* Mr. Griffin's letter to the author, September 1, 1853.

how far it might be depended upon against rodent insects an other vermin.

We now proceed to the important subject of the

LINES UNDER WATER.

These consist essentially of one or more gutta-percha wires, taped or served with tarred yarn, and protected from ships' anchors, fish, drifting trees, &c., by guards of iron, in the form of tubes, chain cables, spiral coatings, or parallel rods.

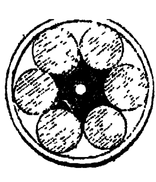
In Iron Tubes.—Across the Rhine, at Cologne, the lines are laid in the river, in a wrought-iron tube, with screw flanges. This was prepared alongside of the bridge of boats, and then lowered into the river. The plan has proved completely successful. Where there is a bridge of boats, as at Allahabad and Agra, it might be adopted with certain success, if a simpler mode were not available.

Iron Spirals.—A spiral coating, of which a drawing has been given (*Fig.* 54), has been used in the Huldee river, 4,800 feet wide, but found too weak to resist the ground-tackle of the native boats, by which it has been frequently injured.

Parallel Rods.

These afford a most effective and easily-applied protection in all rivers which are not navigated by ships of heavy burthen, and which, under circumstances of danger, may have to drag their anchors across the submerged line.

The writer, in 1851 and '52, laid several short lines of this kind across creeks and rivers in Bengal. They are thus constructed. The operation is commenced by extending the wire along one bank of the river, allowing such a length as will provide for the curve of its bed. The gutta-percha line is then served with tape and tar, as already described.



If the stream be navigable, or liable to be dragged by drifting trees, the iron guards should be of $\frac{5}{16}$ inch iron, galvanised. Of these, 6 are arranged with the taped gutta percha wire in the centre, as shown in the cut (*Fig.* 61). A

every foot three turns of thin wire, No. 6, are firmly secured round the compound rod.

The iron rods having been welded and laid out in the first place, a mile of this line can be prepared with ease, without machinery, in a working day. The cost, according to the prices of August, 1852, stands thus:—

6 iron rods, each 10 cwt., at £13 10s. per ton . . .	£40	10	0
Gutta-percha, a mile	17	10	0
Taping	6	0	0
Wire for bindings	2	0	0
Labour	1	0	0
Total per mile	£67	0	0

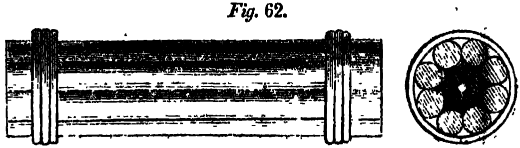
Weight per mile, 3 tons 2 cwt.

These parallel rod lines can be coiled into 6-feet circles, or even less, and unwound without injury, a property which much facilitates their being placed across deep rivers by rafts or boats. Where a bridge of boats exists, or can be provided for the purpose by hiring boats at a reasonable rate, the best plan is to construct the line on the bridge, and then lower it, as has been done at Cologne.

Parallel Guards, No. 8 Wire.

This is prepared exactly as before described, using 8 wires of No. 8 galvanised iron, of the kind known as "best common"

Fig. 62.



wire. This is *now* £28 per ton = to 5 miles. The cost per mile will be accordingly,—

8 iron guards	£45	0	0
Gutta-percha	17	10	0
Taping	6	0	0
Wire for bindings	2	0	0
Labour	1	0	0
Cost per mile	£71	10	0

Weight per mile, 1 ton 14 cwt.

According to present prices, this line is dearer than the one last described, to which it is inferior in strength, but it is much more manageable, from its comparative lightness and its greater flexibility.

Chain Cables.

In the Hooghly and Huldee rivers, which are navigated, the former by heavy native craft, the Hooghly by first-class Indiamen, and in which rivers vessels are often compelled to drag their anchors, as their sole escape from urgent danger, it has been found impracticable to preserve any line from incessant injury, except by attaching it to a heavy chain cable, in the angles of which the gutta-percha wire is secured.

Chain cables have accordingly been laid across the Huldee and Hooghly rivers, 4,800 and 5,200 feet broad. The Hooghly cable is of $\frac{7}{8}$ inch iron, and weighs 18 tons 17 cwt. per mile; value at 22s. 6d. per cwt. (cost of galvanised iron chain, in August, 1852), £524 2s. 8d.

Since the line has been laid in the Hooghly there has been but one interruption. The wire was broken by some violence, the cause of which has not been discovered. The place of the injury was detected with ease, and the repairs of the line effected next day. The accident shows that the chain cable is not an infallible protection, although it is manifestly the best which can be adopted in great navigable rivers, where the violence of the tides and currents sometimes compels vessels to drag their anchors.

Under the rare circumstances in which it may be deemed necessary to adopt this costly system of protection, the gutta-percha wire should have also the parallel wire guards of No. 8 wire, and it should be attached to the chain at every fourth link by two or three turns of No. 8 wire.

SUBMARINE LINES.

Reserving the consideration of the crossing of rivers by masts and overground wires, we now proceed to give some account of the remarkable lines which have been laid or attempted across

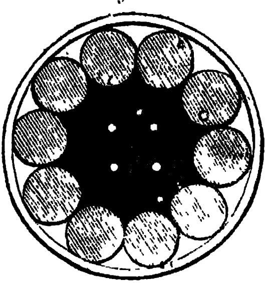
the straits of Dover, between Holyhead and Howth, and Port-patrick and Donaghadee. For specimens illustrative of these details the writer is indebted to the kindness of Mr. Statham, to whom the success of the first submarine line is mainly attributable.

The first attempt to cross the Channel was in August, 1850. Mr. C. J. Wollaston and Mr. T. R. Crampton were the engineers. The copper conducting wire was No. 14 gauge, covered with gutta-percha, so as to measure ½ inch diameter when complete. A drum or roller, sufficiently large to contain the whole quantity (25 miles) was erected, with suitable breaks, &c., on board a steam-tug, the "Goliath," and on the 25th August, one of the wires being made fast at Dover, the vessel steamed across, and the same evening the other end was landed at Cape Grinez, on the French coast. Messages were constantly passed during the voyage, from the ship to the English shore, and *vice versâ;* and from the two shores after completion of the undertaking; but on the following morning it was discovered that the want of some outer protection to the wire was fatal to permanent success. A piece of this wire, washed up in December, 1852, is in the author's possession, its gutta-percha coating perfectly unaltered after two years and three months' immersion in the sea.

The fact of telegraph communication across the Channel having been effected, was sufficient plea for the parties who had risked so much in the experiment to apply to the French Government for a renewal or extension of the grant, which was conceded conditionally that on or before September 1, 1851, a permanent telegraph should be in working order, and so continue to work daily for three months. Some time previous to this date, the Gutta-percha Company perfected the method of *double* covering, by which better insulation is produced with a much smaller quantity of gutta-percha. No. 16 gauge copper wire was selected, and twice coated with gutta-percha, ¼ inch; every coil being subjected by Mr. Wollaston to a test from a battery thirty times as strong as was needful for telegraphic purposes, and found to be faultless. Four of these wires were then laid together with a slight twist. Spun-yarn, saturated in a mixture of Stockholm tar, and a small proportion of pitch and oil or tallow, being

wormed into the interstices, and served round the exterior, so as to form a perfect cylinder, around which ten galvanised iron rods, No. 1, were laid or twisted. (*Fig.* 63.)

Fig 63.



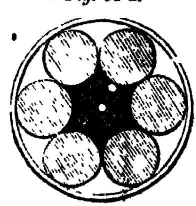
The serving with spun-yarn and covering of iron wire was performed by Messrs. Newall and Co., of Gateshead, at their works at Wapping. On September 24, at noon, the coiling of the cable (25 miles in length, and weighing about 180 tons) into the hold of an old man-of-war steamer, the "Blazer" was completed, and she was immediately taken in tow by two steam-tugs, which conveyed her from the Thames to the South Foreland, the starting point from the English coast, arriving about 3 a.m. on the 25th. At 7 a.m. the tugs were attached to the "Blazer," and steamed away towards Calais, at the rate of about 4 miles per hour. This was found to be too great a speed for the wire to be well uncoiled from the hold, and was consequently reduced to about 2½ miles per hour. About 11 o'clock a considerable swell of the sea, and some wind, which continued to increase during the remainder of the day, rendered the operation of paying out exceedingly difficult, and caused sundry mishaps, which only proved the capabilities of the cable to withstand very hard usage. During the whole of the afternoon, the gale increased, and about 6 o'clock, when within two miles of Sanngate (the intended terminus on the French side), it became absolutely necessary that the "Blazer" should let go her anchor. This was done, and the old vessel, now very light, rode for 24 hours during a severe gale, when she was forced to throw overboard the remaining portion of the cable, and sheer off the coast.

No time was lost, weather permitting, in hauling up the end of the cable, and drawing it in as near as possible to the shore. This operation was successfully accomplished in the afternoon of the 26th; and as it was suspected that they might not be able to bring the cable close enough to the shore to meet the land

wires to Calais, a quantity of the gutta-percha wires, laid together somewhat like the core of the cable, was securely joined on. On bringing this ashore, and attaching the wires to the instruments, everything was found to be eminently perfect; instant communication between the two countries at once commenced, and has continued without interruption to the present day.

Through the kindness of Mr. Wollaston, the author has been permitted to witness the *testing* of this line on the 23rd July, 1852. The cable was cut for the purpose in the cave at the South Foreland, and the insulation of each wire proved, by the process described at page 67, to be perfect in every respect.

Fig. 64 *a.*



The success of the Dover and Calais submarine telegraph gave great confidence to other projectors of submarine telegraphs.

On June 1st 1852 Messrs Newall and Co., having manufactured a *small* cable (*Figs.* 64 *a*, 64 *b*. 65), secured one end of it in a cleft in the rocks near Holyh d, and after a successful run

Fig 64 *b.*

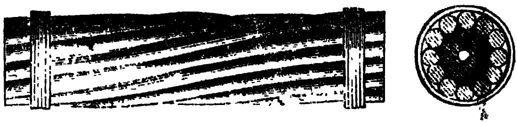
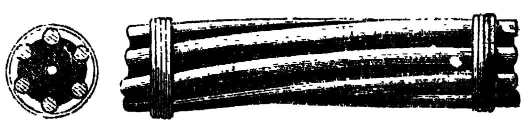


Fig. 65.



across, telegraphed from Howth Harbour to London (the distance across sea being 60 miles) the same evening. It is to be regretted that the success of this enterprise was but brief. From some cause, as yet unascertained, in one week all telegraphic communication between England and Ireland ceased.

This line contained but one gutta-percha wire. Near each shore this was protected by six strong wires (*Fig.* 64 *a*), but there was no inner serving, and the gutta-percha line suffered extreme compression. Further out the line had a coating of 12 thin wires (*Fig.* 64 *b*). For the centre of the line there were but six protectors of very thin wire (*Fig.* 65).

In the autumn of the same year an attempt was made by the English and Irish Channel Submarine Company to lay a hempen cable, enclosing two gutta-percha covered wires, between Portpatrick and Donaghadee; but here again the experiment failed.

About the same period Messrs. Newall and Co. manufactured, for the English and Irish Magnetic Company, a cable somewhat similar to the Dover and Calais one, but containing *six* of the gutta-percha double covered wires; but as only ten galvanised iron wires were applied outside, it was necessary that the covering of gutta-percha should be thinner. In October, Messrs. Newall attempted, in boisterous weather, to run this cable across from Portpatrick to Donaghadee, and, having succeeded in safely depositing 17 miles of it, were compelled to desist. The cable was consequently cut, communication with the Scotch coast having been kept up to the last moment. The prevalence of winter tempests has prevented any attempt being made to complete the communication. (*Fig.* 66.)

Fig. 66.

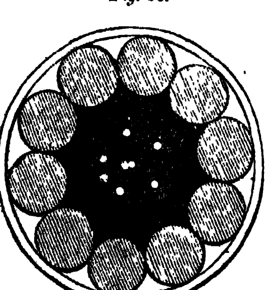
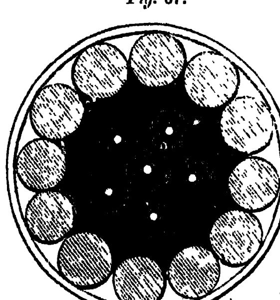


Fig. 67.



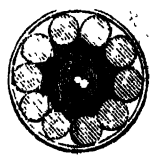
A 3-wire cable is now in course of construction, to be laid across the Great Belt by the Danish Government, who have

already placed underground about 300 miles of gutta-percha covered wire coated with lead.

A 6-wire cable, with 12 iron wires ungalvanised (*Fig.* 67), as an outer covering, or protection, is now completed, and only waits suitable weather, when it will be submerged between Dover and Ostend, by the Submarine and European Telegraph Company. The International Telegraph Company have contracted for gutta-percha covered wire, intended to be laid between Lowestoft and the Hague. In consequence of the great distance (120 miles), and the difficulty in obtaining a vessel sufficiently large to carry safely a large cable of this length, it is proposed to run a number of small cables (*Fig.* 68) across, having say six of these twisted together, and laid out a few miles from each shore, where there is danger to be apprehended from vessels anchoring.

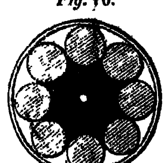
Fig. 68.

Fig. 69.



Each of these cables contains one gutta-percha double-coated wire of No. 16 guage, of gutta-percha No 1, covered with tape, pitch, and sand, by Mr Physick's process; again served outside this with six strands of yarn, soaked in Archangel tar and oil, The outer wire covering consists of ten (*Fig.* 69) No. 8 best charcoal galvanised iron wire. The diameter of the entire is ⅝ inch; the weight per mile. 1 ton 19 cwt. 2 qrs. 6lbs.; length of sea to be crossed, 107 miles; greatest depth of water, 32 fathoms.

Fig. 70.



Several small cables for river crossings have been sent to America, and are reported as perfectly successful.

In *Fig.* 70 is shown the section of one of these lines protected by 8 iron wires, and intended for the crossing of the Mississippi, above New Orleans.

SUBSTITUTES FOR GUTTA-PERCHA.

The very high price of the gutta-percha covered wire, and the rather precarious nature of the supply of this substance, have led to the institution of many experiments on substitutes.

The Earl of Dundonald has recently recalled attention to asphaltum, with a preparation of which substance he has coated some specimens of wire. The cost, it is stated, would be very much below that of gutta-percha.

Asphaltum, pitch, and resins of various kinds, have been made the subject of experiments, on a very large and practical scale, by the author and by others. The official reports show that these experiments met with but slight success, and they lead further to the inference that asphaltum is very inferior to gutta-percha in insulating power, however carefully it may be manufactured.

Liability to cracks and fissures, difficulty of packing and transmission, are also dreaded so much as to render it necessary to subject all such preparations to very rigid trial on a large scale before their adoption for extensive public works. At least 20 miles should be submerged in a river for several days, and then its insulation tested by 360 couples, in the mode detailed in page 67. Packages of one mile or more should be made up in cases, and exposed for some weeks in an apartment heated to 90° at least. Such trials, if satisfactory, would warrant much larger attempts, the success of which, from the abundance and cheapness of asphaltum, would prove of the highest importance in promoting the extension of the electric telegraph.

Dr. Riddell, of Bombay, in a paper lately published in the journals of that city, states that the milky juice of the *Asclepias* or *Calotropis gigantea* (Mudar), a wild shrub common all over India, supplies, when dried before the sun, a substance having the properties of gutta-percha.

The *gutta trap*, the produce of an *Artocarpus* (jack tree), at Singapore—the *atti jegota (Ficus racemosa)*, and *Mangegatu (Ficus Indica)*, of Vizagapatam—also the *Kutimandoo*, of the

same locality, produced by an *Euphorbia*, are all mentioned in the "Reports of the Juries of the Great Exhibition," page 74, as deserving of trial as substitutes for gutta-percha and caoutchouc.

When we remember, however, the close affinity in chemical composition, and resemblance in many properties, between these two substances, and then consider that, for the object of our attention caoutchouc has failed as signally as gutta-percha has succeeded, we are led to conclude that extreme caution is necessary in affirming the existence of any substitute without subjecting this to experiments *on a very large scale.* The introduction of the gutta-percha tree into Bengal, and the promotion of its cultivation, are measures which would appear to deserve the attention of Government.

PART IV.

INSTRUMENTS AND OFFICES.

As the plan adopted for the *construction* of the great lines now about to be commenced has been determined on, on the experimental data obtained from the Calcutta and Kedgeree lines, so the instruments to be employed at first, and the system of organisation of the offices, rest upon the experience of the perfect and uninterrupted success with which the public service is now carried on in the several telegraph offices at Calcutta, Bishtapore, Atcheepore, Diamond Harbour, and Kedgeree.

These offices have been open for correspondence since the 6th October, 1851. The amount of business they transact, and the importance of their functions to Government and the community, are practically shown by the official documents quoted as we proceed.

The instruments and system in use have been adopted on experiments carried on from January to October, 1851, on the line from Calcutta to Diamond Harbour, where two experimental offices were established for the observation of the effects of lightning and rain on the working of the different instruments and batteries under trial.

By these observations it was very soon found that, to work any line *uninterruptedly*, and with that steady certainty of operation indispensable for public purposes, it was an essential condition that the instruments employed should be of the very simplest kind, so that their construction, adjustment, and repairs might be effected without the employment of expert mechanists and electricians—by boys fresh from school, knowing little or nothing of mechanism or electricity—and only aided by the rude blacksmith or carpenter of a native village.

The furious thunder-storms which prevail from March to October in Bengal, and the strong constant currents of natural electricity flowing in the north and south lines, by deranging,

reversing, or destroying the polarity of the magnetic needles, by converting temporary into permanent magnets, and by burning the fine wires of every kind of instrument, proved in a few weeks that to use the complex and delicate apparatus employed in England, France, and America, an experienced European mechanist should be stationed at each office. This, the extreme unhealthiness of many out-stations, the paucity of such mechanics in Bengal, and the high value of their services, rendered an impracticable arrangement. Our sole alternative became accordingly the simplification of the instruments, or abandonment of the undertaking.

The instruments tried during the experimental season were chiefly such as those in use in England and America, and others on the same principle as those simultaneously or subsequently proposed in England and France, by Messrs. Henley, Dering, Dujardin, and others. All proved alike unsuitable. It may be said that these instruments having been constructed in Calcutta, not imported from Europe, did not afford fair results. Little weight as can be allowed to this objection by any disinterested or competent person, it has still been considered proper to send out from Europe a collection in duplicate of nearly all the telegraphs now in actual use, or proposed on good authority, supplied by the best makers, in most cases by the inventors or patentees. These instruments will be submitted to trial and observation during a sufficient period, and officially reported on, in comparison with those in use at present on our lines. The result will determine which shall be preferred for final adoption.

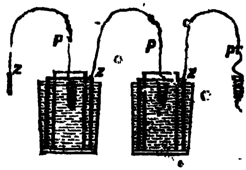
Meanwhile, for the provisional organisation of the offices and correspondence, the system of the Calcutta lines will be adopted till further orders. We shall accordingly describe minutely the instruments and arrangements of the Calcutta and subordinate offices, as the guide to be followed in all those to be subsequently opened.

THE BATTERY.

This is a set of 6 to 10 elements of the nitric acid and platinum wire kind described at page 13, and of the several parts of which a drawing is here given.

The battery is placed on a teak-wood tray, and is enclosed in a wooden cupboard, on a table, at the east end of the signal-room; this cupboard is let into the wall, through which an aperture is made to permit the fumes from the battery to escape into the air. The cupboard is kept closed, and thus all annoyance from the acid is effectually prevented. Two thick copper wires lead from the zinc and platinum ends of the battery into grooves in two wooden battens, nailed to the floor, one foot apart. In these grooves the wires are laid in melted pitch, and are led to the right-hand corner of the table in the centre of the room, on which the signalling instruments are placed.

Fig. 71.



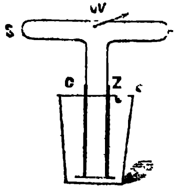
The same arrangements are made when sulphate of copper batteries are used. (*See page* 11.)

The line from Diamond Harbour, which we will designate as the *telegraph* line, enters the room at the south side; also a wire leading from a plate of iron sunk in the river Hooghly, outside the office door.

Both these wires are led into the office, and laid on the floor, in grooved wooden battens, and their ends are led to the left* corner of the table.

It is evident that if the wires from the battery are made to touch those from the telegraph line and the river in the direct course shown in *Fig.* 72, the Diamond Harbour line will receive a *positive* state of electricity from its contact with the platinum side of the battery, which would be shown by the deviation of a galvanometer needle at Diamond Harbour, say to the right side, or from north to *west*. (*See page* 5.)

Fig. 72.

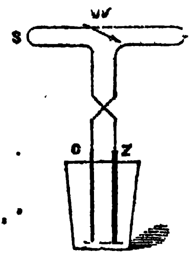


But if the order of contact be reversed, so that the zinc side

* In speaking of the right or left side of any object, we mean that opposite to the same side of the observer: thus, the left of the table is that side opposite to the observer's left hand.

wire touches the Diamond Harbour line, and the platinum side the river line, the Diamond Harbour rod will receive *negative* excitement, and the galvanometer needle of Diamond Harbour will deviate, say to the left, or from north to *east*. (*Fig*. 73.)

Fig. 73.

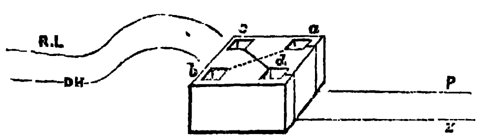


The battery wires are accordingly made to touch the telegraph and river lines, either directly or crosswise, so as to send positive or negative currents along the telegraph line, and deflect the needle at Diamond Harbour east or west at pleasure, by the *Reverser* shown in the accompanying figures.

REVERSER.

The wires from the *battery* (*Fig*. 74) are joined by two binding screws to two wires inserted in a block of wood 2½ inches square. Four hollows, half an inch deep, are cut in the wood, and these hollows are joined diagonally by copper wires let into the substance of the wood, and most carefully insulated from each other by melted cement in the wood, but exposing a clean metallic surface in each cell. The battery wires are thus connected, wire *p* with the cells *a* and *b*, and wire *z* with *c* and *d*.

Fig. 74.

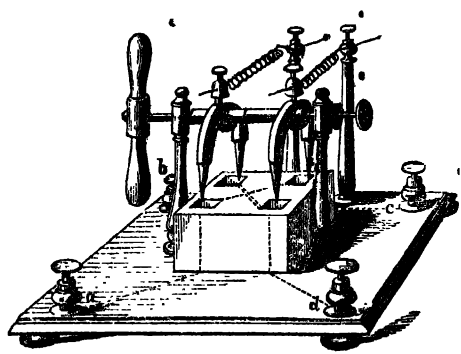


The hollows are filled with mercury. It is obvious that if the telegraph and river lines dip into *b c*, the line to Diamond Harbour, D H, dipping into *b*, will receive electric excitement from the platinum or positive side. But if the telegraph and river wires dip into *a d*, the Diamond Harbour line, D H, will receive electric excitement from the zinc or negative side.

The dipping of the wires into the mercury might be effected by the hand directly, but this would be slow and irregular; the telegraph and river wires, D H and R L, are accordingly fastened by two binding screws to two brass pillars, each 4½ inches high, having a spiral coil of strong elastic brass wire 3 inches long, ½ inch diameter, attached to its top at a right angle. The brass spiral is joined by a screw to a fork with two steel points, 1½ inches long, and 2 inches apart. These steel points, when at rest, are ½ inch above the surface of the mercury in *b d* or *c a* at each side. The steel points must be brazed into the brass piece, not screwed in.

The forked terminals of both the brass spirals are borne on the same axle, supported on two pillars. But the terminals must be carefully insulated from metallic contact with each other by an ivory collar on the axle.

Fig. 75.



A vertical handle on the axle, completes the apparatus. The handle is worked by the bent forefinger and thumb, and thus the telegraph and river terminals may be made to touch the battery terminals alternately in opposite directions; and when the hand is withdrawn, contact with the battery ceases altogether.

With this apparatus opposite currents can be sent along the line with a rapidity in manipulation equal to that of a brilliant

player on the piano. The instrument is very substantial, and never requires further adjustment than an occasional tightening of the screws, adding a drop or two of mercury to the hollow receptacles, or cleaning the surfaces of these with a feather. It is necessary to use steel points to the terminals, as brass or copper would be rapidly destroyed by the mercury. The steel points should be rubbed bright with sand-paper every morning.

These *reversers* are very substantially made at the gun-foundry at Cossipore, near Calcutta, to a uniform pattern, and cost 12 rupees, say £1 4s., each.

THE TELEGRAPH.

This consists of a coil of fine wire, on a card or ivory frame; a magnetic needle, with a light index of paper pasted across it; two stops of thin sheet-lead, to limit the vibrations of the index; a supporting board, eight inches square, and a square of window-glass, in a frame of wood, or a common glass tumbler placed over it as a shade, to prevent the index being moved by currents of air.*

The office boys, with the assistance of a native carpenter, make up these telegraphs at a price not exceeding two shillings each. The documents appended to these remarks prove that in delicacy and rapidity of action they are at least equal to the costly needle instruments in use in England. We now proceed to describe their construction in minute detail.†

The Frame.—This is a piece of teak or mahogany, 8 inches square and 1 inch thick, with a hollow groove cut in its centre, 2¼ inches long, ½ inch wide, ¼ inch deep. A ledge of the same wood, 1 inch wide and ⅜ inch deep, surrounds the frame, leaving the inner surface 7 inches square. This is stained black with ink, to make the motions of the index more conspicuous.

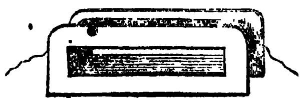
* The use of the *punkah*, or suspended fan, in Indian offices, renders this glass cover indispensable.

† No credit whatever is claimed for the introduction of this simple telegraph by the writer. It is, in truth, the original galvanometer of Oersted, invented in 1819, with a slip of paper appended to indicate its vibrations. Oersted's galvanometer need never have been departed from, but, by making it vertical instead of horizontal, a legal argument was found for claiming a *patent* right, as if for a new invention. The English telegraph is nothing more than Oersted's coil and needle.

The Coil.

This consists of 50 feet of the finest silk-covered copper wire, wound on a frame of card 2 inches long, $\frac{1}{2}$ inch broad, $\frac{3}{8}$ inch deep in the open part. An edge or flange of card, $\frac{3}{8}$ inch wide, is attached to it at each side, to keep the wire in its place.*

Fig. 76.

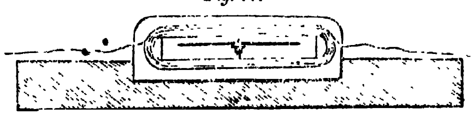


The frame may be of ivory, or thin wood; sandal or satin-wood answer very well. Brass or other metal is objectionable, as any fault of covering in the wire may lead to casual contacts with the frame. The winding of the wire commences at the lower left corner, and the wire in coiling is led from left to right, as the hands of a watch would move in the same plane. Each wire lies close and parallel to the next, without overlapping till one layer is laid. The winding then continues in the same direction for a second and third layer, and so on till the fifty feet are wound.

Coils of this kind are prepared in a few minutes, and a dozen or two are always kept ready in reserve. They are made by the boys for four annas (sixpence) each.

Two inches of each end of the coil wire are now stripped of their silk covering, by being rubbed with sand-paper. Lastly, the continuity of each coil is tested in the precise manner de-

Fig. 77.



scribed at page 66, *Fig.* 41, substituting the telegraph coil for that of the gutta-percha wire.

The coil is mounted in the frame by inserting its flange in

* This wire is drawn and coated with silk by the native gold-lace men for about one penny per yard.

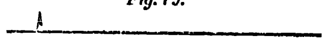
the groove, so that the floor of the open part of the coil is level with that of the frame. (See *Fig.* 77.) It is now ready to receive the magnetised needle.

The Needle.

This is 1 inch long, $\frac{1}{12}$ inch wide, of the thinnest steel, and fitted with a little brass cap, turned to a true cone, to receive the point on which it is balanced. These needles are of hard-tempered steel, and are magnetised by a single contact with the electro-magnet described at pages 23 and 24, excited by 6 of Daniel's, or nitric acid cells. The native jewellers and cutlers make these little magnets very neatly for about fourpence each. The brass cone should be carefully examined, to ascertain that it is smooth, and no burr on its inner surface.

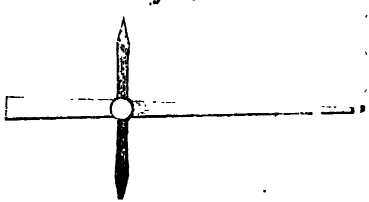
Fig. 78.

Fig. 79.



The magnet is now to be balanced on a steel point, $\frac{1}{8}$ inch high (these are nipped off with cutting pliers from common sewing needles), soldered into a slip of thin copper, 3 inches long, $\frac{1}{2}$ inch wide. It will be found at first that the north end of the needle *dips* considerably. To counteract this the south end is touched with a feather dipped in lac varnish, which dries rapidly, and this is repeated till equilibrium is attained.

Fig. 80.



The needle is completed for use by fixing to it an index of paper,* 2 inches long, tapering from $\frac{1}{8}$ inch to a point, and

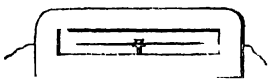
* Cut from glazed letter-paper.

fastened at right angles on to the needle with lac varnish, so as to be in equilibrium, and that its sharp index end should be to the *east*, when the needle, placed on the pivot, settles north and south, its north pole being opposite the observer's right hand, the observer facing the west.

Fig. 81.

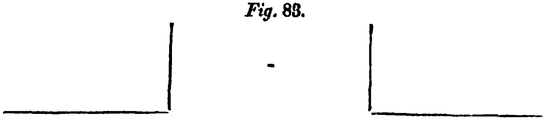
The coil frame is placed north and south, and the needle is now introduced by sliding the end of the copper strap into the opening in the frame. It should now be carefully examined, to ascertain that the movements of the needle are free in every direction.

Fig. 82.



To limit the vibrations of the paper index a *stop* is placed at each side. The stops are made of a strip of thin sheet lead, or copper, ¼ inch broad, 1½ inch long, and turned up at a right angle, so that 1 inch rests on the board, and ½ inch is vertical. For ordinary practice these stops are placed each at ½ inch from the index, thus:

Fig. 83.



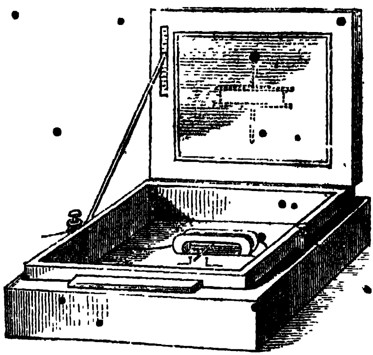
But the distance may be widened or narrowed at pleasure in an instant.

A wooden lid, glazed with window glass, completes the instrument, and, when closed, makes it secure for travelling.†

† In some of these telegraphs we have inserted a mirror inside the lid, which, when placed at the angle shown, gives a vertical image of the needle index (see dotted line in *Fig.* 84). This was done on the mistaken idea that the movements of the English vertical needles were more easily learned and read than with those placed horizontally.

Our telegraph is now ready to receive signals, say from Diamond Harbour, where we will suppose to be placed a battery and reverser, this connected at one side with the telegraph line, another with a water line, the Hooghly river.

Fig. 84.



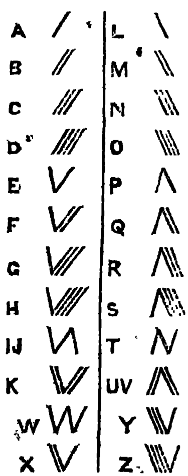
One end of the fine wire of the Calcutta coil is now joined to the terminal of the telegraph line; the other end of the coil wire is joined to the river line. The instant this is done the index, previously pointing east, deviates strongly to the *right*, and remains hard up to the stop. This proceeds from a natural current of electricity flowing in the north and south lines, both overground and subterranean, but not observed as yet in the east and west lines on our circuit.

To counteract this deviation, and bring the index to the centre, a small steel magnet is placed on or near the frame, and approximated or removed, according to the strength of the line current, the south pole of this magnet being opposite to the north pole of that in the telegraph coil. The bar is 4 inches long, $\frac{1}{2}$ inch broad, $\frac{3}{16}$ inch thick.

Besides counteracting the line current, the use of this magnet gives great liveliness of movement to the signal needle, which, when deflected by a telegraph current, on this ceasing, is brought back instantly to the neutral or middle point.

We have now traced the arrangement in detail, and the telegraph is ready. Every time the signaller at Diamond Harbour makes his reverser points dip into the mercury at either side, the index at Calcutta moves to either stop. When the Diamond Harbour reverser is out of the mercury, the Calcutta index returns to the neutral or middle point. We can count any number of these deflections or *beats* at either side, or alternately. In practice, no more than 4 beats are given at one side in succession. The alphabet is thus given: a *right hand* or *left hand* beat is that opposite the right hand or left hand of the observer; and the connecting wires are all so arranged that the movements of the top of the handle of the reverser, and the movements of the telegraph indices, are always to the same side, a right-hand movement of the top of the handle giving a right-hand beat of the index of the distant telegraph.

Fig. 85.



Alphabet.

The first ten letters are founded on the Roman numerals, with slight modification in the ninth and tenth letters.*

The second series of ten letters is exactly the reverse of the first.

Letter W is given in the natural order by four alternate beats—left, right, left, right. This letter is used as the testing letter in the adjustment of the apparatus, to discover whether the wires are all adjusted in the proper order.

The reverse of W, or M, signifies the end of a despatch.

This alphabet differs much from that used on the English lines. Being based on the Roman numerals, it may be said to be known already by every one who can read. We find, accordingly, that its practice is acquired in two or three days, while the arbitrary

* The tenth letter, *k*, may be described as a double V, or fifth.

English alphabet is always learned with difficulty, and many lads cannot master it at all.* (*See page* 120.)

In commencing correspondence, alternate beats are given, say for half a minute. This is termed a *roll*. It is answered by a roll from the distant station.

Seven alternate beats are the *service* or *urgent* signal.

The despatch is then given word by word, each spelled in full, no contractions being permitted. Even numbers are spelled, like the sum in a cheque, to prevent the possibility of mistake, in important communications.

The alphabet is not engraved on the instrument, as is done so uselessly in England. An alphabet is just as necessary on each page of a printed book. No signaller is ever allowed on duty on our lines until he can read without such assistance.

Each word is separately acknowledged by the signals **V**, "understood," or **Λ**, "not understood;" but we must now explain by what means the despatch and reply are alternately sent through the line.

The Turn-plate.

By this contrivance the telegraph line is brought at pleasure into association with the battery, so as to *send* a message, or with the telegraph, to *receive* one, thus:—

Fig. 86.

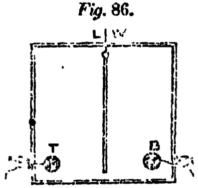
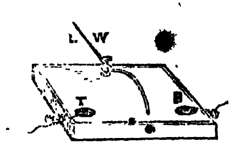


Fig. 87.



A piece of bent iron wire is attached to a binding screw to which the telegraph line is connected. This wire is bent so that it can be placed alternately in either of two hollows con-

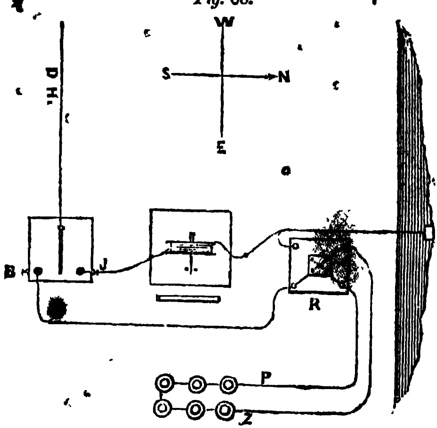
* In the English single needle alphabet, given in Mr. Walker's Manual, p. 78, letter *a* is given by two beats to the right, //; letter *d*, the fourth letter, by \/, one left, one right beat. The alphabet is entirely an arbitrary one, and gives no clue to its recollection.

taining mercury. One of these mercurial pools is connected by a wire with the copper or platinum side of the battery, B. The other pool is connected with one terminal of the coil, T, the second terminal of which proceeds to the river line, thus :—

If the line wire D H, from Diamond Harbour, be moved into the mercury pool B, it is in contact with the battery through the reverser R, and is ready to despatch a signal. If the line wire D H be moved into the mercurial pool T, it is in contact with the Calcutta telegraph, which is thereby made ready to receive a signal.

Thus the currents sent from Calcutta do not pass through the the Calcutta telegraph, but proceed direct from the battery to Diamond Harbour. The currents from Diamond Harbour, again, do not enter the Calcutta battery, but pass at once through its telegraph to the river.

Fig. 88.



The annexed plan, *Fig.* 88, shows the battery, reverser, telegraph, turn-plate, and line attachments, all in their relative places. The signaller sits between the battery and telegraph, with his face to the west.

In the English offices, all the currents from a given station pass through their own instruments before entering the line.

This practice is most objectionable. It interposes the resistance of two or more coils of fine wire; and if there be derived currents from imperfect insulation on the lines, the electric action on the telegraph needle at the near station is so powerful as frequently to derange its polarity, and render it necessary to take out the needle for re-magnetisation.

The use of the turn-plate above described obviates this evil. Being made of a piece of wood, 6 inches square, and 1 inch thick, with three binding screws, and a few inches of wire, its value may be fairly estimated at one rupee—two shillings.

Steel springs and brass studs for contact might be used in this turn-plate, and in the reversers instead of the mercurial pools. But springs are liable to fracture, and can only be replaced by expert workmen, while a bent wire and a little mercury are procurable in every village.

ROUTINE OF DUTY.

The usual routine of work in the Calcutta offices will best exemplify the use of the above arrangements.

At gun-fire, half-an-hour before sunrise, the signaller in charge examines his battery and connecting wires, and sends a prolonged roll to Diamond Harbour. This is answered, to show that Diamond Harbour is in readiness, and that the line, batteries, and instruments are in good working order. Questions are then passed to and fro as to the strength of the beats; and the distant stations request each other, if necessary, to add to or diminish the battery power.

Each station then places its line wire in contact with its telegraph, and the signallers take their watches in turn, each for one hour, when he is relieved. The youngest lads on probation take their turn at this duty, and if unable to read the signals themselves, they ring a hand-bell, and call the "reader" on duty the moment the needle is seen to move.

At 9 a.m., at noon, and at 6 p.m., Calcutta time is telegraphed along the line by 9, 12, or 6 beats, corresponding with those of the Calcutta clock, and common American clocks are thus used with confidence to regulate the duties of each office.

At a quarter to 10 a.m., at a quarter to 12, at a quarter to

4 p.m., and at a quarter to 7 p.m., the state of the weather and tide at the out-stations are signalled to Calcutta, and are published in the printed bulletins issued at 10 a.m., noon, 4 p.m., and 7 p.m.

All the movements of shipping in the river are forthwith reported, posted on the office gates, and printed and circulated to subscribers, at intervals of three hours during the day. Casualties are instantly made known to the Master Attendant. Arrivals or departures of vessels belonging to particular firms are notified to the parties interested.

Signal flag-staffs are erected on the roofs of the stations at Atcheepore, Diamond Harbour, and Kedgeree. The signallers at these offices are instructed in Maryatt's code of marine signals, and Captain Bedford's Hooghly River code. Communication thus takes place by signal with the shipping. When long or important despatches have to be sent on board by boat, a plain red flag at the station is an *imperative* order for the vessel passing to anchor or heave to, to receive the communication.

During the day despatches are incessantly flowing along the line on public or private business.

The first notice of every event in the Burmese war has been received through the Kedgeree and Diamond Harbour offices—a formidable test of their efficiency, subjecting these to the immediate scrutiny and personal observation of the highest functionaries of the Government of India.

Night Correspondence.

The evening gun from Fort William closes the day duties of the offices along the line. This takes place at 8 p.m., from the 21st of September to the 21st of March, and at 9 p.m. in the other months.

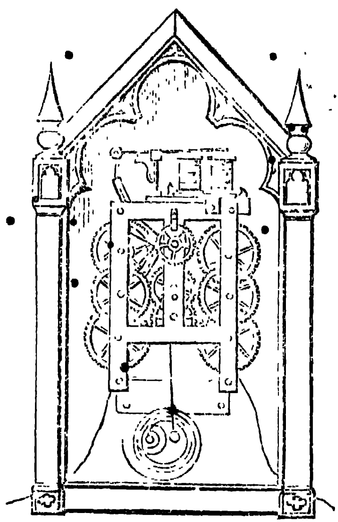
An alarm clock is now set, and the *watching* of the instrument ceases. The senior signaller in charge, and one junior signaller, sleep in the signal room, beside the instrument table. The ringing of the alarm never fails to arouse the sleepers.*

* At out-stations it may be found prudent to post a sentry in the signal room by night, to call the signallers when the alarm rings.

The Alarm Clock.

This is a common American clock, wound up daily. A small electro-magnet, surrounded with thick wire, is placed below a moveable piece of tinned iron, so that when this is attracted, the fly of the clock is released, and its bell tolls unceasingly while the magnet is excited.

Fig. 89.



The electro-magnet of the clock is excited by the battery of the *same station*, which sends a powerful current through its wire when a circuit is completed through this by a *wire* index moved by a galvanometer coil, the same in all respects as the telegraph already described, except that the index is of platinum wire instead of paper.

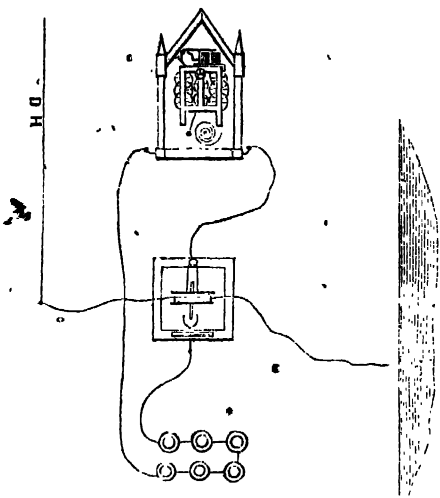
A copper wire is led from the platinum side of the office battery to a screw soldered to one terminal of the alarm magnet.

Another copper wire is led from the second terminal of the

alarm magnet to a screw attached to the copper strap and point on which the telegraph needle is balanced.

A loop of platinum wire is substituted for the leaden stops, and the end of this wire is connected with the zinc side of the station battery. The alarm telegraph is then set on the line, just in the same manner as the day one, with its regulating steel magnet, to keep the index in the middle, and free from the stops.

Fig. 90.



A current flowing along the line, by disturbing the telegraph needle, causes its metal index to touch the metal stop at either side. This contact allows the whole current of the station battery to flow round the alarm magnet. Its keeper is attracted, and the bell rings as long as the distant current is applied.

The log-book of the Calcutta telegraph office contains numerous official proofs of the certainty with which this system ensures night correspondence. As an instance, we may adduce a visit made by the Superintendent of Marine, Captain Rogers, by order of the Governor-General, at 11 p.m., on the night of

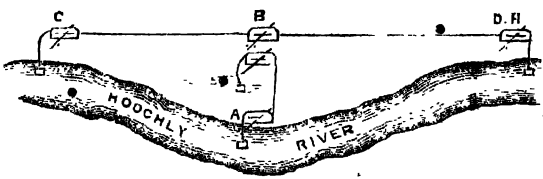
the 14th February, 1852, to the Calcutta office, to learn if the "Phlegethon" steam-vessel had landed a despatch from the King of Ava at the Diamond Harbour post-office. In *four* minutes the answer was obtained from Diamond Harbour, although all the signallers were in bed and asleep, and no sentry posted, when Captain Rogers entered the Calcutta office.

Intermediate Stations.

Having thus described the instruments, usual work, and arrangements in the Calcutta office—all of which are the same in any station at the *end* of any given line—it is necessary now to advert to those employed at *intermediate* stations.

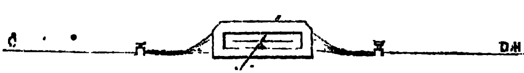
Half way between Calcutta and Diamond Harbour, at the missionary station of Bishtapore, a branch line turns off to Atcheepore, on the Hooghly river, a frequented anchorage, the site of an important powder magazine, and the place where the overland mails to and from Bombay cross the river.

Fig. 91.



This intermediate station was established instead of running a direct line from Atcheepore to Calcutta, in order to afford practical instruction to signallers in the management of similar places on the great lines.

Fig. 92.



The first peculiarity in the arrangements is that the telegraph coil used at Bishtapore is *interposed* in the line from Calcutta to Diamond Harbour, and has no earth connection. (*Fig.* 92).

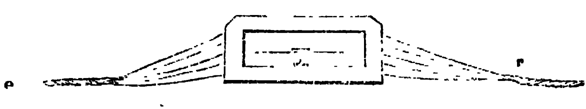
All signals to and from Calcutta are thus passed through the coil, and are legible by its index.

This *interposition* of coils is common on the English lines, especially those for the railway service—for instance, the North Kent system, having five chief stations on one line, and two shorter groups of six and seven stations each on a second line.*

As the coils employed in the English offices, especially in the instruments of the older pattern in use in those referred to, consist of several thousand feet of the finest wire, the resistance thus created is enormous, and the necessity for perfect insulation absolute. *(See page 19.)*

It has already been stated that the coils used in Bengal contain no more than fifty feet of wire, a length which has been found sufficient to effect the requisite movements of the needles and indicators. Every foot of wire added to this is a useless resistance; but, to diminish this resistance still further, the coils of *interposition* are wound in a different manner. The fifty feet of fine wire are cut into five equal lengths. One is wound on the card frame from left to right; the second, third, fourth, and fifth then added from left to right also, but each as a separate coil. The ends are then twisted together. Thus the current subdivides itself into five streams; the resistance is thus reduced to that of ten feet of wire of five times greater section. *(See page 19.)* The needles are still moved with the full speed required.

Fig. 93.

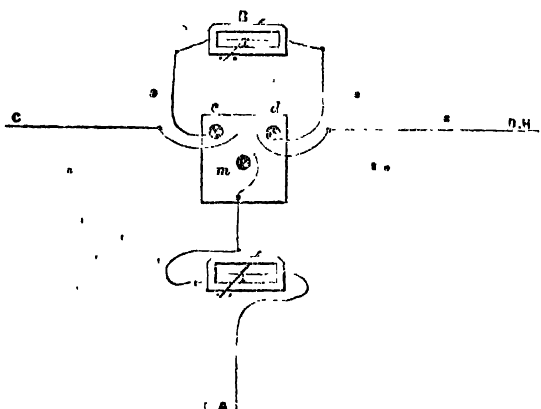


This instrument, like that at Calcutta, is *watched* by the probationers by day in hourly watches, but its movements are not read until its own special signal is noticed, which is the index remaining hard up to the *left* side. When this signal is seen, the *reader* is called, and Bishtapore is placed in communication with Calcutta. (*Fig.* 94.)

* "The Electric Telegraph," by C. V. Walker, Esq., p. 47.

In a piece of mahogany 1 inch thick and 6 inches square, are three hollows, ½ inch deep, containing mercury (*c*, *d*, *m*). The line from Calcutta dips by an iron wire in *c*, also one terminal of the interposed telegraph. The line from Diamond Harbour dips by an iron wire in *d*, also the second terminal of the interposed coil.

Fig. 94.



An iron wire from the Atcheepore line and telegraph is also brought to this central apparatus. All these iron wires are bent, so as to be easily elongated.

Thus, by lifting C and D H from their mercurial pools, and placing their ends in the pool *c*, the Bishtapore telegraph is thrown out of the circuit, and Calcutta and Diamond Harbour placed in direct correspondence. Whenever this is done, the time is specified from the head station, for which the intermediate one is to be excluded, say for five or ten minutes, when the current is to be again directed through the interposed coil by replacing the line wires in *c* and *d*.

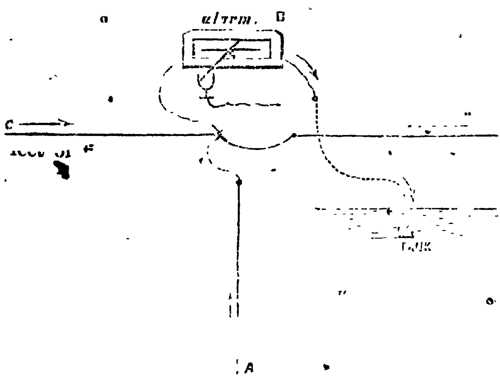
If the wires C and A be inserted in the pool *m*, Calcutta and Atcheepore are brought into direct correspondence.

If D H and A be placed in *m*, Diamond Harbour and Atcheepore are in direct correspondence.

On the table where this central piece is placed is also the terminal of an earth plate, which can be used at pleasure with any of the instruments, so that, for instance, while Calcutta is corresponding with Atcheepore, Bishtapore may communicate with Diamond Harbour.

One alarm clock suffices for an intermediate station, corresponding say with three others. The line wires are all placed in contact with one terminal of the alarm coil. The second terminal of this is joined to the earth.

Fig. 8.



The arrangements thus described are all made with ease on one table, the several wires being led to others in grooved wooden battens on the floor. The table should be placed so that one observer can watch the entire.

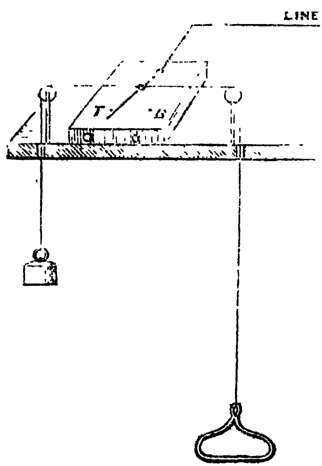
As the distance between the stations may be very great, the description above given applies as well to any other group, say Benares corresponding with Calcutta to the S.E., Agra to N.W., Mirzapore to S. It has been found on our present lines that an intermediate station of this kind requires two good readers and three or four probationers, or apprentices, to ensure its efficiency.

Double Lines.

We have now described the office arrangements and working in fine weather. As far as our observations yet extend, fogs or rain do not affect the work, although no insulators are used. This proceeds from the massiveness of the metal line, and this being a *single* rod, and exempt from the disturbance of the currents from other lines.

We reserve for future consideration and directions, on the completion of the first long section of our *double* line, the peculiarities of arrangement this will call for. At present it suffices to say that the double line will be generally worked as two distinct single lines would be, each having its separate instruments and operators.

Fig. 96.



The English double needle instruments, and the French double semaphore telegraphs, require two line wires besides the earth circuit, but may be regarded as two single instruments in

one frame, one worked by the right, the other by the left hand. Two sets of the Bengal instruments may thus be worked side by side, but the use of the *reverser* with the left hand requires much practice, and is with difficulty mastered. The turn-plate in this case is also different. It consists of two upright steel or brass studs, 1 inch high, set on a piece of wood 1 inch apart. A piece of strong clock spring is attached to the line wire; this, in its ordinary state, rests against the stud T, and is thus associated with the telegraph. If pulled to the right, so as to touch B, it is in contact with the battery. (*See Fig.* 96.) This movement is effected very conveniently by a cord attached to the spring, and let over a pulley through the table, and ending in a stirrup or pedal about an inch from the floor on which the foot of the signaller rests. He thus, by a slight pressure of the foot at either side, turns his right or left line on at pleasure, his hands being left free for the manipulation of the reversers.

By this arrangement we maintain the advantage of directing the currents on the lines without their passing through our own telegraphs.

Instead of a steel spring, a common brass or copper wire may be used, having an elastic spiral of brass wire, or a string and weight, to bring it back to contact with the telegraph stud.

In the English system the alphabet of the single line differs from that for the double line, and is so arranged that the same letter in the double code may be represented by *three* beats at most, while in the single code some of the letters require *four* or *five* beats. More importance is conceded to this than it deserves. A little practice enables a signaller to give even a five-beat letter in one second clearly and distinctly; while in the letters having several beats at one side, these are given more by a flutter or vibration than by a separate movement.

The acceleration really effected by the double-line instrument is chiefly by its enabling the distant clerk, if he understands a word, as very frequently happens, by its first letter or two, to "cut in" by the unoccupied line and needle, and give the sign "understood." In this way forty or even fifty words are telegraphed and read in a minute by first-rate operators. But in all well-regulated offices the signallers are forbidden to exceed

twenty words per minute, as that is considered the limit of accuracy in taking down in writing the message as received.

It will be seen, in the report of experiments made at the Dover station with the Bengal instrument, that in practised hands this can be used to transmit eighteen to twenty words in a minute.

It is the practice, however, on the English lines, to *repeat back* all messages, in order to secure the accuracy of the despatch. The offices charge half-price for this repetition, and without this will not insure the accuracy of the message. The repetition is effected at a quicker rate than the despatch; still, practically, this reduces the total speed to ten or twelve words per minute. Repetitions of this kind have never been practised or required in our Indian lines, and up to the last reports we have not been charged with any serious error in the transmission of despatches for Government or for the public.

Codes or Cyphers.

Some remarks are necessary here as to the use of codes or cyphers for correspondence by the electric telegraph.

For *codes* such as Maryatt's or Bedford's, or any other preconcerted between two correspondents, the needle telegraph answers perfectly, provided the code be divided into numbered chapters, sections, and units, and each number telegraphed be spelled in full. Secret codes of this kind will be compiled for the use of the different Government departments, which will ensure the transmission of despatches without their meaning being intelligible to the signallers.

Another mode of secret correspondence much adopted in America and in England is that of assigning to certain words a different meaning from their apparent one. Thus "Calico has shrunk in width by one hundred and twenty threads," may mean, "Opium has fallen in price one hundred and twenty rupees." Mercantile firms may have their own special vocabularies of this kind.

Using words having each a substantive meaning, errors are

almost completely avoided. The context of the word gives certainty to the signaller. But if meaningless words, or irregular groups of letters, be employed, mistakes are certain to occur. An opium speculator in Calcutta, soon after the opening of the telegraph offices, instructed his correspondent in China to land a despatch at our outside station at Kedgeree, directing the letter *x* to be telegraphed three times if opium had risen in price. The lad on duty in Calcutta receiving from Kedgeree the message, "Inform Mr. —— *x*" and not being prepared for this mode of correspondence, telegraphed back, "Not understood," and received an angry "*x*, *x*, *x*;" in reply. The message was sent in this state. Mr. —— purchased opium, and lost considerably. A single *x* was his signal for a fall, *x* repeated three times for a rise of prices. This case is cited to show that it should not be attempted to convey secret messages by the use of single letters, or repetitions of the same letter, or by arbitrary groups of letters, devoid of any actual meaning.

ATMOSPHERIC ELECTRICITY.—THUNDER STORMS.

We have now to advert to the effects of atmospheric electricity and lightning on the instruments employed in our offices, and the mode of protecting these from injury. This subject has already been noticed at pp. 33, 41, 49, 50, and 51, which the reader is requested to peruse again in connection with the following observations.

We have there described the general effects of lightning on the lines and instruments, the lightning conductors to be used on the temporary and permanent *lines* in connexion with the *posts*, and *outside* the tents or offices.

On the experimental line constructed in 1839, the terminals of which were placed in the library of the Botanic Garden of Calcutta, the visitations of lightning were so frequent and terrible that on more than one occasion it became necessary to detach the line while the storm was raging.

In the lines, partly subterranean, partly overground, at present in operation, it is found that the subterranean line is abso-

lutely exempt from liability to lightning discharges, beyond a minute portion of a flash conveyed from an over-ground line, or the effects of currents, *induced* by lightning flashes striking the earth in the vicinity of the line.

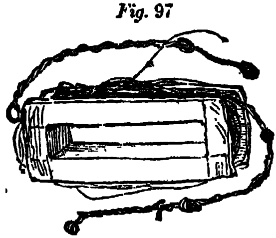
These effects on the *subterranean* line are manifested in the offices by small bright sparks on the protectors attached to the instruments, by derangements of the magnetic state of the needle and electro-magnets, by smart shocks to the operators, and by the ringing of the alarms at night.

Where the overground line is united with a subterranean one, a flash striking the former explodes through the insulating coating to the nearest wet earth, tears off the coating for some feet, and affects the uninjured part of the line by a fraction of the direct discharge which passes to the distant offices. This fact was first observed in March, 1852, on a line laid across and below the Huldee river. It has led to the construction of a floating conductor, described at page 34, one of which should be attached to the commencement of every subterranean and river line, so that the lightning may be intercepted, and the place of injury to the line found without difficulty.

At these points of junction of overground and subterranean lines a covered hut should be constructed, and a well dug for the floating interceptor. This hut should be in charge of a watchman.

On the *overground* lines now in operation in Bengal, several visitations have occurred, but beyond the splintering of a few bamboos, and the melting of coils, no injury has been done up to this time, and the coils have escaped all harm since the introduction of the instrument protectors described as we proceed. The most severe effects have hitherto been observed at the Bishtapore station, where the instruments are *interposed* in the line.

Fig. 97

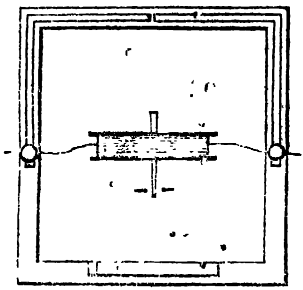


The accompanying woodcut shows the effect of a direct flash on the coil in use on the evening of the 21st March, 1852, at half-past 8 p.m. The flash traversed the in-

strument, burned the card frame, and melted the ends of the wires into beads.*

By reference to *Fig.* 98, the construction of the lightning protector used on our instruments will be understood at a glance. A strip of sheet copper, ½ inch broad, is inlaid on half the ledge of the telegraph, and then cut by a fine file across the middle. The terminals of the telegraph coil are joined in metallic contact to each of these copper straps. A lightning dischaıge of high tension entering the station by the line wire, explodes across the ·, and only so small a portion traverses the coil as to do it no harm.

Fig. 98.

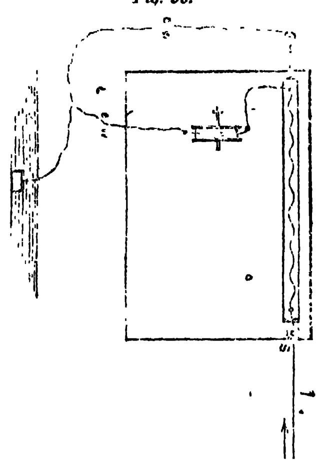


Since this simple protector has been adopted we have not lost a coil in any of our offices.

For the general protection of the persons in the offices the following arrangement is adopted:

Along the edge, and on the surface of the instrument-table, is inlaid a strap of thin sheet copper, 1½ inch broad, one end of which is attached to the earth or river line by a strong and clean metallic connection.

Fig. 99.



* In less than ten minutes, the signaller on duty, Charles Todd, placed another coil in gear, and while the storm was raging, reported by telegraph to Calcutta what had taken place in his office.

The line wire reaching the table in the wooden batten, rises to a binding screw at the corner of the table *s*, to which it is connected. A fine silk covered wire, 20 feet long, wound in a spiral coil one inch in diameter, is led from this screw and extended on the surface of the copper strap, to within half-an-inch of its end, where it turns off to join the end of the telegraph coil. A second strap of copper, precisely similar to the first, is now laid over the extended spiral, and firmly set in contact with the lower strap by wooden or brass cleats screwed on the table.

A flash entering the office has to pass by the fine wire *between* these two straps of copper, and will in every case strike off to these through the silk coating of the wire, and escape to the earth. A flash passing in this manner, may perhaps burn the silk, and bring the fine wire into contact with the copper, thus intercepting the telegraph currents. Should this happen, the upper strap can be removed by turning the cleats, and a fresh wire spiral inserted in less than two minutes, two or three spare spirals being always kept ready for the purpose.*

The inner surface of the copper straps should be roughened by coarse sand-paper, in order to present a multitude of points to the lightning discharge.

To resume, we have at page 41 described the lightning conductor to be attached to each post, 16 to the mile; at page 34, the interceptors to be used outside each office, and at each side of every river or subterranean line; we have here shown the protectors to be used in each office, and for every instrument. All of these are, moreover, of the cheapest and simplest kind, and their efficacy proved by the experience of two years in a tropical country, visited by terrific thunder-storms. The writer has on many occasions witnessed, with deep and grateful satisfaction, the tranquil performance of their duties by all persons employed in the offices, while the atmosphere was in a blaze of lightning, and trees and animals struck down within a few paces of the house.† But it must be emphatically impressed on the attention of every one concerned, that neglect of the simple

* These spirals are made by coiling the wire round a common office ruler.

† These facts are on official record in the log-books of the Calcutta and Diamond Harbour offices.

precautions described will inevitably, in India, lead to the most disastrous results. A telegraph line is a snare for lightning. We can, however, direct the meteor where we choose, or diminish the risk to a degree compatible with the safety of all employed, by the simple appliances thus described.

It is desirable to notice here the lightning protectors generally employed in the English and other offices.

MR. WALKER'S.—The annexed description and figures are taken from Mr. Walker's "Electric Telegraph Manipulation," pages 63, 64:—

"*Fig.* 100 represents the lightning conductor half full size. A is a brass cylinder, 1-16 inch thick (shown in section in the figure), in perfect metallic communication with the earth by a stout wire, and insulated from the conducting wire by a disc of boxwood and a boxwood bobbin. The ends of the bobbin closely fit the inner surface of the cylinder, but it is slightly grooved in its course to receive two or three layers of a silk-covered copper wire, finer than any elsewhere to be found in the instruments. The wire is further furnished with two nuts fitted with points made by gauge to approach almost within hair's-breadth of the cylinder. The boxwood terminations are also capped with brass discs. From the upper disc points approach the earth cylinder, and from the lower end of the earth cylinder points are presented to the disc. The object of the coil of very fine wire is, that, from its tenuity, and from its juxtaposition to the earth cylinder, it shall have a better chance of being burned in an extreme case than either the wire of the bell coil or that of the needle coil.

Fig. 100.

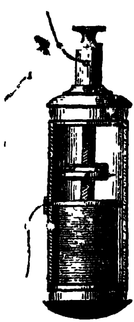


Fig 101.

"The first set of these conductors were placed at Tunbridge Wells Station, and not many weeks had elapsed before a lightning flash entered the station, and it behaved with the apparatus as I had been led to expect. It passed safely through the stout wire, and on arriving at the fine wire it darted off to the cylinder, and by its explosion singed the silk and exposed the wire. In this case the flash was moderate, and the wire was not burned."

Mr. Walker's protectors are used in all the offices of the extensive district under his superintendence, and are also adopted on some other lines in England.

Mr. Highton, in his interesting work on the Telegraph, thus describes the very simple system which he has adopted :—

"These disastrous effects are now entirely obviated. The plan pursued by the author is as follows. A portion of the wire circuit, say for six or eight inches, is enveloped in bibulous paper or silk, and a mass of metallic filings in connexion with the earth is made to surround such covering. This arrangement is placed on each side of the telegraph instrument at a station. When a flash of lightning happens to be intercepted by the wires of the telegraph, the myriads of infinitesimally fine points of metal in the filings surrounding the wire at a station, and having connexion with the earth, at once draw off nearly the whole charge of lightning, and carry it safely to the earth.

"This arrangement at once prevents any danger to the telegraph instrument. Not a coil under the author's charge has been fused where this plan has been adopted. The cheapest method is as follows :—Line a small deal box, say six or twelve inches long, with a tin plate, and put this plate in connexion with the earth; fill this box with iron filings, and then surround the wire (before it enters a telegraph instrument) with bibulous or blotting paper, as it runs through the centre of the box. All high-tension electricity collected by the wires will at once dart through the air in the bibulous paper to the myriads of points in the iron filings, and thence direct to the earth, and thus the telegraph instrument will be rendered incapable of being damaged even during the most fearful thunder-storms that may occur."

Mr. Dering proposes a conductor consisting of two pieces of brass, each $2\frac{3}{4}$ inches long, $\frac{1}{2}$ inch broad, $\frac{1}{4}$ inch thick, grooved on the surface, one longitudinally, one transversely, separated from each other by a double fold of flannel, and one connected with the line wire, *l w*, one with the earth, *e w*, the whole contained in a solid piece of mahogany. A figure is given of this arrangement, which differs in no essential particular from that used by M. Steinheils on the Prussian lines.

Fig. 102.

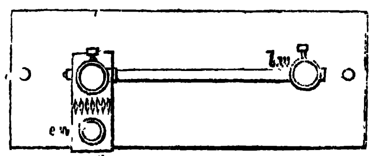
French Method.

At pages 49, 50, 51, we have described the protectors adopted on the lines and *outside* the offices. In the offices each instrument has either of the following contrivances :—

The line wire is led to a brass binding screw, from which is led an exceedingly fine *iron* wire, 2½ inches long, passed through a piece of thermometer tube to a second brass binding screw, the supporting piece of which has eight sharp teeth.*

The earth wire has a similar brass piece with eight teeth, screwed on the same board, the teeth all but touching those of the line wire.

Fig. 103.



A discharge passing through this instrument will burn the fine iron wire, and the excess pass by the points to the earth.

For the double instrument, subsequently noticed, M. Brequet employs the same arrangement, also double, substituting a coil of exceedingly fine silk-covered copper wire for the iron wire in the glass tubes.

M. STEINHEILS, of Munich, has introduced on the German lines a very efficient protector, which we have described at page 53.

In AMERICA, it is stated by the latest authority † that "interruptions from atmospheric electricity have been greatly reduced of late; and it is confidently expected that they will, at no distant day, be entirely overcome. One of the means used at present is by putting on a lightning arrester near the recording instrument. This arrester is formed of a little glass globe, surrounded by a semi-circle of small points like needles, that approach quite close to the ball. These points carry off the lightning to the earth before it reaches the instrument. The diminution of interruptions by thunder-storms has been reduced 30 per cent. by this means alone."

* This fine wire is scarcely visible, and the engraver has omitted it in the cut. † Jones, *op. cit.*, p. 107.

TRIALS OF THE INDIAN INSTRUMENTS IN ENGLAND.

In conclusion of this notice of the Bengal instruments, it is right to state here that these have been subjected to experiment in England, with reference to the distances through which they can be worked, on lengths of line which we could not command in India. The results are shown in the annexed official reports, which we conceive to afford fair reasons for our continuing these instruments in use on our lines pending the official trials of other apparatus.

Experiments by Messrs. Statham, Brunton, and the Writer.

Gutta-percha Company's Works,
18, Wharf-road, City-road, London,
July 7, 1852.

Trial of an Electric Telegraph Instrument, one of those which have been in actual use at the Calcutta Office. Present, Samuel Statham, Esq., Director of Gutta-percha Work; Mr. Richard Law Brunton, Chemist to Gutta-percha Company; Dr. W. B. O'Shaughnessy, Superintendent H. E. I. C. Electric Telegraph lines.

1st experiment, length of line tried, 200 miles, No. 16 copper wire, double coated with gutta-percha, submerged in Regent's Canal; circuit completed through earth by the gas-pipes. Battery used, sand and acid; plates $3\frac{1}{2}$ inches by $3\frac{3}{4}$ inches. A single needle instrument of Cooke and Wheatstone's in the circuit at near end; instrument on trial at distant end of line. With 1 cell the needle was deflected by alternate beats, full range of stops, one inch apart.

2nd experiment, 300 miles same wire, not in water; 200 submerged as above; total, 500 miles; earth circuit. With 1 cell, index moved; with 2 cells, moved distinctly; 3 cells, very distinct, but slow, and not to full range of stops; 4 cells, ranged to stops, but slow. Single needle instrument, Cooke and Wheatstone's, gave no visible deflection up to this point, although at near end of circuit. With 6 cells, and the instrument under experiment, beats strong and distinct, and sufficient for practical work; 12 cells, too strong, index recoiled from the stops.

Certified to be correct.

SAMUEL STATHAM,
RICHARD L. BRUNTON,

Experiments on Submarine Line between Dover and Calais.

Submarine Telegraph Office, Dover,
7, Clarence-place, July 23, 1852.

The four wires of the submarine telegraph between Dover and Calais being joined together, making a length of about 130 miles of continuous wire, signals were produced as follows, on Dr. O'Shaughnessy's instrument, one of the East India Company's single needles being included in the circuit.

One pair of plates—signals clearly visible.
Two ditto—very fair.
Three ditto—good.
Four ditto—strong and effective.

This experiment was tried in the presence of Dr. O'Shaughnessy, Mr. Statham, of the Gutta-percha Company's Works, and A. D. Evans, telegraph clerk at Dover, who stated he could without difficulty communicate and read at the rate of twenty words per minute,* by means of instruments of the construction adopted by Dr. O'Shaughnessy: of this I have myself no doubt.

CHARLTON S. WOLLASTON.

Letter from C. V. Walker, Esq., Superintendent, South Eastern District.

South Eastern Railway, Electric Telegraph Office,
Tonbridge, August 18, 1852.

MY DEAR SIR,—I have much pleasure in giving you my opinion of the experiment tried here on the 7th and 11th insts., with your horizontal galvanometer, by yourself, in my presence, and in that of my clerks and assistants.

Your instrument was inserted in the circuit of the through wire from London to Dover (88 miles), and the effect of the signals passing and repassing between the termini was observed on your needle. On the 7th I saw it receive messages between Tonbridge and London, as on the 14th between Tonbridge and Dover, using our apparatus (in the absence of your working key) for transmitting the electric force, but reading off from your needle, which I did very successfully. I also tested your horizontal needle against our usual vertical needle, with a weaker force, and found the sensibility in favour of yours. It appears to me that if we can ourselves read off from an horizontal needle, conveniently adjusted (which would be easily ac-

* Single needle; equal to forty words per minute with a pair or double needle wire.—W. B. O'S.

complished), we should gain in several ways. The needle being much smaller, on a pivot, is more delicate. It requires (as you have proved to us) a very few feet of wire, instead of many yards, for the coil, and each yard of wire saved is equivalent to increasing the distance to which a given electric force can act profitably. The great advantage of an horizontal needle, which, as a practical man, I can fully appreciate, is the facility with which it can be renewed, and magnetised when affected by lightning. This, with me, at this season, is a serious matter. I have 80 telegraphs and stations, and 211 needles, and have but four stations with assistants competent to magnetise, more from the difficulty of unshipping the needle than aught else; but with the use of such simple arrangements as yours (and I do not know why it has been overlooked heretofore), we could get over this difficulty.

I am, my dear Sir,
Very sincerely yours,
CHARLES V. WALKER.

To Dr. O'Shaughnessy.

INSTRUMENTS IN USE IN ENGLAND AND OTHER COUNTRIES.

But a brief notice is required here of the instruments in use in England and other countries, the object of these pages being solely that of directing the construction of the Indian lines, and the first organisation of the offices for correspondence.

Through the liberality of the Court of Directors of the East India Company, a fine collection has been formed in duplicate of nearly all the instruments actually in use in England or other countries; and some have been added which have not been as yet tested by actual experience, but which are considered of good promise.

On the completion of the first long line in India, all these instruments will be fairly tried, and, according to the result, the best will be adopted for general use.

TELEGRAPHS IN USE IN ENGLAND.

Cooke and Wheatstone's Needle Telegraphs.

These instruments are employed almost exclusively on all the lines worked by the *old* Electric Telegraph Company.

This telegraph consists of a coil of fine wire, covered with silk, placed vertically, enclosing a small rhomboidal needle of magnetised steel, mounted on an axis, which also bears an index needle outside the coil. The vibrations of this index, checked by a stop at either side, give the beats required for the formation of the alphabet.

In the same frame is also contained the Current Director, which sends the battery current along the line, each station passing its current through its own as well as through the distant instruments. This *Director* is a very complex arrangement of metal cylinders and springs, which could scarcely be understood by description or figures, without the opportunity of dissecting the instrument itself.

These telegraphs are either single or double. A single one is shown in the annexed cuts. *Fig.* 104 exhibits the exterior. *Fig.* 105 the internal arrangements. The current proceeding

Fig. 104.

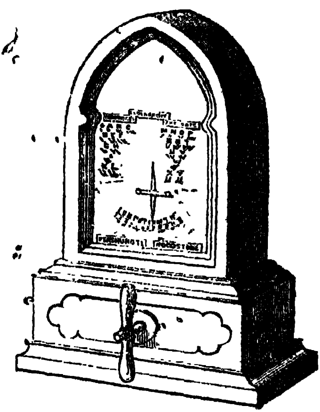
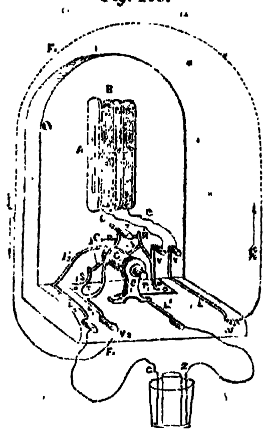


Fig. 105.



from the copper side of the battery enters by the brass strap l^2, and proceeds by a spring to a metal cylinder, C, on a prolongation of which outside the frame the signalling handle is mounted. From C it passes to R, enters the coil B, circulates through it,

and leaving it by C, enters the line wire as indicated by the arrows, passes on to and through the distant instrument, re-enters the near one at V[2], passes by the spring t, descends by R, and returns to the zinc side of the battery by l^1 at z.

The projecting studs on the cylinder C are so arranged with reference to the springs, that by deflecting the handles to the right or to the left, you reverse the direction of the current on the line, and bring this into contact alternately with the copper or zinc side of the battery, so as to render the line positive or negative at pleasure.

The coil is made in two pieces, one of which being moved aside gives access to the magnetic needle, for the purpose of refreshing or changing its state of magnetism when this is deranged by atmospheric electricity, or by the violent action of the battery currents so improperly sent through the near coil in the practice of the English offices.

In the telegraphs of this kind first used on the English lines, the length of wire on the coils was enormously great. Two magnetic needles were used, the external one being placed with its poles in the opposite order to those of the internal one. The needles were long and light, and, as at present, so weighted that they always resumed the vertical position by the force of gravitation when the electric current ceased to cause a deflection to either side.

The needle telegraphs now most in use have been much improved by shortening the coil of wire to a few hundred from many thousand feet—by shortening the inner needle—discarding the external one, for which a light ivory index is substituted—and mounting the coils so as to facilitate their being moved and opened.

Notwithstanding these improvements, it is amusing to see how the natural tendency of patentees and instrument makers to render their apparatus as complex as possible, has succeeded in changing the simple and beautiful multiplier of Schweigger into the difficultly intelligible apparatus now before us.

The best instruments of this kind which the writer has seen are manufactured by Mr. W. Reid, of University-street, London, at £6 each for single, £12 for the double kind.

The rate of signalling obtainable with these instruments by a thoroughly practised signaller, reaches twenty words with the single, forty with the double telegraph, in one minute. But much of this "fast" signalling is accomplished by bold guessing and "cutting in," and the English offices accordingly repeat back all messages from the distant station, at a heavy additional charge to the correspondent, as the condition on which alone they guarantee the accuracy of the despatch.

The double needle-instrument requires the use of two line wires, but has the advantage of being worked by one operator.

The alphabet in use with these instruments in England being an arbitrary one, is learned with difficulty by most persons, by many cannot be mastered at all. The needles are exceedingly apt to become deranged, and correspondence is then generally interrupted till an expert person can be sent from head quarters to open the coils, remove, remagnetise, and replace the needle. If this causes serious interruptions in England, with its railway speed of travelling and its well-manned head stations, we can readily estimate what would take place with such instruments in India, where travelling is considered fast when it reaches six miles an hour, and expert mechanics are to be found only at the capital cities.*

Next in importance of the instruments in use in England, is

Bain's Chemical Marker.

This instrument causes blue dots and lines to appear on a band of paper unrolled by clock-work. The combination of these dots and lines gives the alphabet, and the signals are thus permanently recorded.

The current from the distant station passing by a single wire, is received by a small fine wire electro-magnet (see page 25) placed horizontally, and before the poles of which is placed a small piece of soft iron, poised on delicate pivots, and kept slightly apart from the electro-magnet by a fine hair-spring of spiral brass wire.

* See Mr. Walker's Letter, page 181.

When the current passes, the attraction of this piece of iron makes two platinum points touch each other. When the current ceases, the hair-spring removes the iron, and the platinum contact is broken.

These platinum points serve to establish and direct the current from the station or near battery on the chemical marking apparatus.

This consists of clock-work, which unrolls a tape of damp paper previously soaked in a strong solution of equal weights of nitrate of potash, yellow prussiate of potash, and muriate of lime. This band is unwound from a brass roller in metallic contact with the zinc side of the *station* battery.

A piece of iron wire, supported by a binding screw, rubs on the upper surface of the prepared paper. This iron wire is so arranged with reference to the copper side of the station battery, that the movement of the platinum points above described causes the positive current of the station battery to pass by the iron point through the prepared paper. The iron is corroded by the nitric acid of the saltpetre, and Prussian blue is formed by the prussiate of potash. A dot is produced by a momentary contact, a line or dash when the contact is somewhat prolonged.

This is an excellent instrument, both in principle and in practical use. It is at present used for direct correspondence between London and Glasgow. From twenty to thirty words can be transmitted and recorded by this apparatus in a minute.

The chief objection to its general use is the representation of letters by dots and dashes intelligible only to a trained operator.

The price is moderate: a pair made by Mr. Reid cost £32. The clock-work was substantial and good, but the arrangements of the connexions for throwing the local battery current on the marker were excessively and needlessly complex, and had to be replaced by a different one before the instrument could be made to act with a single wire and earth circuit.

The instruments above described, with the double needle telegraphs of Cooke and Wheatstone, are employed to the exclusion of all others on the great lines belonging to the old Electric Telegraph Company.

Mr. Wheatstone's *step by step* apparatus, which by a very in-

genious arrangement of electro-magnets and clock-work caused a message to appear letter by letter on a wheel, or a revolving pointer to pause before the letter required, is no longer in use in England. In a very modified form it may be still seen on some of the foreign railways. Its movements were found to be too slow and too subject to derangement to permit of its general adoption.

Henley's Induction Telegraphs.

These telegraphs are in use on lines constructed for the purpose between Liverpool and Manchester, and between Dublin and Galway. Lines of subterranean conductors are also being laid for the same company between London and Manchester. In Henley's telegraphs the signals are given by the beats of a needle to right or left, the index following the movements of a small steel magnet of peculiar form, alternately attracted and repelled by a soft iron electro-magnet when excited by a distant current.

The currents are supplied by an *induction* apparatus, consisting of a very powerful compound magnet of steel bars, permanently magnetic. A piece of soft iron is alternately made to approach and recede from the poles of this magnet by a handle. The soft iron is wound with several thousand feet of fine insulated wire. When the soft iron approaches the permanent magnet it becomes a magnet for the time, and on being suddenly removed this temporary magnetism ceases. A very intense electric current is thus generated in the fine wire, is directed on the line, and reaching the distant station, circulates round the signal electro-magnet, and causes the deviation of its index.

These instruments are exceedingly well made by the patentee, Mr. Henley, St. John's-road, Islington, and cost £28 each. They are worked by two wires, and need no voltaic battery. According to the statement of the patentee, they are capable of transmitting signals under circumstances which would stop the action of other instruments, such as defects of insulation on the lines giving rise to loss of electricity by derived currents.

The writer in 1839 made numerous experiments on the trans-

mission of signals by *induced* currents with apparatus different in no essential character from that patented by Mr. Henley. The results were not satisfactory. Again, on the lines now in operation between Calcutta and Kedgeree, and on which no insulation is resorted to, while *induced* currents of high intensity are totally lost, very feeble voltaic currents work the instruments perfectly in the thickest fogs and heaviest rain.

These facts render the successful application of Henley's telegraphs on the Indian lines a very doubtful question; but the instruments sent out shall have a careful and fair trial.

Dering's Needles.

Mr. Dering, of Welwyn, has patented several "improvements" in electric telegraphs, and some instruments of his construction are now in successful operation on the London and Dover subterranean lines.

In his needle telegraphs he places "the centre of gravity of the needle immediately below the centre of motion, on the principle of the short pendulum"—a good arrangement, but by no means a novel one. Needle instruments of this kind have been made in Calcutta, and tried on the experimental lines from the first.

Mr. Dering also places the pivots in an angular opening, not in round holes, and this he states diminishes the oscillations which the needle makes on returning to the vertical position.

Mr. Dering, in some instruments, uses coils so wound that the needles are attracted or repelled by the sides of the coil, not deflected in the usual manner. This is identical with the principle and arrangement of Mr. Allan's telegraphs subsequently noticed, and both are but a modification of one of the common instruments used by lecturers in demonstrating the principles of electro-magnetism, and figured by Dr. Roget in the Library of Useful Knowledge more than twenty years ago.

In the telegraphs by Mr. Dering now in use in the London and Dover offices, an electro-magnet is employed to deflect the needles suspended as above described. He specifies in his patent that the length of the soft iron is not to exceed the diameter, and by this means, he asserts, all residual magnetism

is completely prevented. He further uses no connecting piece of soft iron to form the legs of the electro-magnet, which amounts to dismissing the horse-shoe magnet, and employing two bars in its stead.

For the results of our experience as to the inefficiency of these means in preventing residual polarity, the reader is referred to pages 25 and 26.

Instruments in every essential respect the same as Mr. Dering's have been already in use on our lines, and given up in consequence of their liability to derangement by natural currents and the effects of lightning. Nevertheless, in order to test the plan with the utmost fairness, six of these telegraphs have been purchased and sent to India at the very moderate cost of £40.

The contrivance by which Mr. Dering directs the battery currents on the lines, and alternately reverses their direction, is a very great improvement on the complex plan adopted in the ordinary telegraphs, and figured at page 132.

There are many other inventions by Mr. Dering, which exhibit great ingenuity, but which do not require notice here, as they have not been adopted in actual use, and are considered far too complex to be employed in India.

Highton's Telegraphs.

Several patents have been taken out by the Messrs. Highton for telegraphic instruments, and the British Electric Telegraph Company has been formed to work these inventions.

At present Highton's "commercial telegraphs" are in use on a line between Leeds and Stockton. Lines are in construction for the same company from Glasgow, *viâ* Dumfries, Carlisle, Newcastle-upon-Tyne, Leeds, and Manchester to Liverpool, and are thence to extend to London.

In an interesting little work on the electric telegraph, recently published by Mr. E. Highton,* the inventions of that gentleman and his brother, the Rev. H. Highton, are described generally, but not in sufficient detail to be readily intelligible without drawings or actual inspection of the apparatus.

* "The Electric Telegraph, its History and Progress." By Edward Highton, C.E. 12mo, pp. 179. Weale, Holborn, London, 1852.

Instead of needles Mr. Highton employs small light steel magnets of the horse-shoe shape, which he states are far superior to the old form.

Mr. Highton's "commercial telegraphs" cost £45 each. They are remarkably ingenious and the writer regrets that Mr. Highton's numerous engagements prevented the supply of a pair requested for trial on the Indian lines, within the period allowed for their delivery.

Brett's Printing Telegraph.

This exquisitely-beautiful instrument is in partial use in the London, Dover, and Calais offices of the Submarine Company.

Using *one* wire only, it prints its despatches in capital letters on a band of paper delivered by a train of clock-work actuated by weights. In practised hands it prints about ten words, or fifty letters, in a minute.

By a very simple and effective mechanism, on the printing of each letter, the train returns by a bound to the zero or starting point, so that errors are very rare and only affect a single letter without deranging all in sequence, as was the case in the older "step by step" apparatus.

This instrument consists essentially of a vertical electro-magnet, which, alternately by *reversal of its poles*, attracts and repels a very light steel magnet of a double horse-shoe shape, the movements being about one-eighth of an inch in each direction, and taking place in a horizontal plane.

Each movement is communicated by a vertical spindle to an escapement pin, which liberates a train of clock-work, bearing a small wheel with twenty-four types arranged on its circumference. Each movement of the escapement pin allows one tooth or type of this wheel to present itself in succession at the top of the wheel under a band of paper. While any letter is thus brought into position, the axle of the type-wheel winds up a small weight, and simultaneously lifts the piston of a little water pump. When the letter has become vertical, the pause made by the signaller permits the water piston to descend, and this liberates a second train of wheels, and a combination of eccentric levers, by which the band of paper is made to touch the type, is

drawn forward far enough for the next letter, and the small weight previously wound up is set free, bringing back the type-wheel to the zero or starting point.

It would be almost impossible, even with accurate drawings, to render the mechanism of this most beautiful machine intelligible to ordinary readers. A pair has been supplied for trial in India for £100, and Mr. Brett offers all subsequently ordered for half that sum.

The advantage of having despatches *recorded* in ordinary characters, legible by all educated persons, and needing no previous training in the signaller, are too self-evident to require much comment. The mode of arrangement and sending of despatches by Brett's instrument can be learned by any one in an hour. The plan, moreover, allows of abbreviations in words and sentences, which could not be permitted with instruments leaving no record of their work, or one in arbitrary symbols intelligible only to a few trained signallers.

On lines much employed for the transmission of Government despatches on diplomatic, judicial, or financial business, the printing system would prove of the utmost value. Despatches may be conveyed in any language. In India, Latin or French would be commonly employed for Government purposes, and thus the despatches made unintelligible even to the clerks on duty.

To balance these advantages there is the extreme complexity and delicacy of this machine, which would require two skilful mechanics to be retained at every station where it might be employed. Even in England this seems to have much impeded its introduction. The American instrument of House, subsequently described, shows that Brett's telegraph might be much improved, simplified, and strengthened, if the interests of the patentees permitted their combining in one instrument, parts of the mechanism now used separately in both.

The next English instrument to be noticed is

Allan's.

These are not as yet in actual use in working lines, but a company is understood to be formed for their introducton.

In one form of Mr. Allan's inventions very small coils of wire

are made to act externally on a compound cruciform steel magnet, and by its alternate attraction and repulsion, actuate an index by the beats of which the signal is communicated.

The most remarkable of Mr. Allan's inventions is one in which a revolving pointer pauses before the letter to be signalled in an alphabet engraved on the dial.

The pointer is moved by the attractions and repulsions alternately exercised on a magnetised piece of steel by an electro-magnet, and communicated to a pair of small ratchet wheels, very delicately constructed and pivoted, and on the axis of which the pointer is mounted.

Should an error arise in the receipt of a despatch, the receiver, by turning off the distant current and using his own, sends on the pointer to the starting letter, and at the same this is notified to the sender by the cessation of the movements of his own index.

The power employed is an *induced* current of very great intensity, generated by an electro-magnet of soft iron excited by thick wire, and a battery of three or four large couples. Outside the thick wire is a fine wire coil. The making or breaking of the primary currents in the thick wire generates intensity currents in alternately opposite directions in the fine wire, and these are directed on the line to the distant station.

Two sets of Mr. Allan's instruments have been supplied for our collection, and for experiment. The needles at £21, the lettering pointers at £50 the pair.

The earliest application to telegraphing of the *induced currents* generated by electro-magnets, was by the writer of these pages in 1839. His experiments are described in the Journal of the Asiatic Society of Bengal, published in Calcutta in that year. The arrangements by Mr. Allan are, however, highly original, and promise in practice to afford valuable results.

FRENCH INSTRUMENTS.

Breguet's.

But two kinds of instruments are employed in the French offices. One for railway purposes and short lines, shows letters

on a dial by a revolving pointer. This instrument is worked by an electro-magnet and one wire, is difficult of adjustment, and slow in its operation. But it has the advantage of being available in the hands of all persons who can read, without tedious preparatory training.

For the purposes of Government and the community generally, an instrument is exclusively used, the invention of M. Foy, and made by M. Breguet, which is admirably adapted to the circumstances of a country which previous to the invention of the electric telegraph possessed a most extensive and perfect system of semaphoric lines, with a numerous and highly efficient body of signallers, and a complete system of codes, cyphers, and private modes of correspondence, the inventions of the celebrated brothers Chappe, and unknown in other countries.

M. Foy, the Director-General of the semaphore lines, with M. Breguet's able aid, devised accordingly the electric *semaphore* now in use, which reproduces all the signals of the old masts and arms, and thus renders the officers and books of the former system available for the public service, with all the advantages of the swiftness of electricity and its new application to night correspondence.

The telegraph of Foy consists of two electro-magnets, each having a piece of soft iron balanced before it. When excited by an electric current this iron is attracted. When the current ceases the iron is drawn back by a delicate spiral spring of brass wire, the strength of which is regulated by a silk thread, made tense or lax by the movement of a pin turned by a watch-key.

A spiral steel spring, like that of a clock, and similarly wound up, is connected with an index which, moved by the spring, can take any one of eight positions on a dial, by means of an escapement with four projections and four hollows. Every time the electro-magnet is excited, one of these projections passes. Thus the attractions by the electric action cause four, the reaction of the brass spiral four, of the eight steps which each index arm takes on the dial.

Thus, with two wires and by the use of two electro-magnets, sixty-four positions may be shown. And we have the means of giving the alphabet and numerals, each letter or number by

its own single sign, there remaining thirty signs still available for the prefixes, terminations, conjunctions, &c., of the most ordinary occurrence.

Thirty words spelled in full are thus telegraphed with ease in one minute.

These admirable instruments are now in use in the Submarine office in Cornhill, in direct correspondence with Paris. They are best worked by the nitric acid or sulphate of copper batteries, of the former 50, of the latter 100 couples being required for the longest lines.

A complete set of two of the lettering or railway telegraphs, two of the electric semaphores, a pair of loud alarms, with four sine galvanometers, and various pieces of duplicate magnets and springs, have been supplied for the Indian collection by M. Breguet at the following prices:—

	Francs.
Two semaphore telegraphs (recepteurs)	820
Two contact arms (manipulateurs)	440
Two lettering telegraphs (recepteurs)	400
Two contact discs (manipulateurs)	200
Two alarms	480
Two sine galvanometers	100
Two ditto, more simple	40
Two lightning conductors	100
Two ditto, more simple	40
Total francs	2,620
or . . .	£104 16s. 8d.

AMERICAN TELEGRAPHS.

We have next to notice the telegraphs employed in the United States of America, the most remarkable of which are also used in Baden, Prussia, Austria, and Russia.

These telegraphs are named after their inventors, Mr. Morse and Mr. Royal House.

Morse's Telegraph.

This instrument is used in more offices and over a greater length than is the case with all the other telegraphs employed at

this time. In the United States alone the lines worked by these telegraphs are 15,835 miles in length.

It consists of two vertical electro-magnets. One, wound with fine wire, receives the distant current, and moves an iron armature through a space of scarcely more than a hair's breadth. This movement, however, is sufficient to establish contact between the wires of a second electro-magnet wound with thick wire, and interposed in the circuit of a local battery of four to eight large elements of the nitric acid or sulphate of copper kind.

This second electro-magnet, thus powerfully excited, attracts with great force a massive iron lever terminating in a sharp steel point. This point strikes against the under surface of a band of paper, delivered by clock-work, and on this band the point indents in relief a series of dots and lines from which a conventional alphabet is formed.

Signals are thus transmitted at the rate of twenty-five words in a minute, and recorded as received.

The blows caused by the secondary or local magnet are so powerful as to afford a loud alarm.

A vertical galvanometer needle is placed in circuit in the best instruments, in order to measure the intensity of the distant current.

In the United States these instruments are commonly worked through lines of 500 miles. In winter, when these are insulated perfectly by the frost, 1,500 miles have been signalled through in a single circuit.

A Morse telegraph made at New York, and procured for our collection, cost £11, but is coarsely made and badly put together.

At Furtwaugen, in the Black Forest, about thirty miles from Strasburg, these instruments are made in a very superior style by Laurenz Bob, and sold at 120 florins, or about £10 10s. These telegraphs are fitted in glass cases, provided with reels well filled with paper, and mounted on a substantial table, with the requisite wire terminals and screws.

They are also very well made at Stuttgard, by Geiger, for 180 florins, about £14.

Two instruments in the East India Company's collection were

procured from Berlin, through M. Siemens, and bear the names of "Siemens and Halske" as the makers. Price, £54 the pair. In point of finish and completeness of all the requisite fittings, these instruments cannot be surpassed.

House's Printing Telegraph.

This is one of the instruments in large actual operation, and is now worked in America on 2,200 miles of line. A very fine one, manufactured by Messrs. Richards, of New York, has just been received for the Indian collection, and successfully tested on the London and Dover line of the Submarine Company.

This instrument was invented in 1848, and, although patented in England by Mr. Brett, in partnership with the inventor, has never been seen in operation out of America till the arrival of the specimen in our collection.

In America, it is stated on good authority, that about one hundred telegraphs of this kind are now in operation, and several important lines are worked exclusively by its means.

Like Brett's telegraph, House's prints its work on a band of paper in Roman capitals. But the instruments differ essentially in all their details of construction and manipulation, and House far excels Brett in rapidity of work, being capable, in practised hands of conveying sixty words, or 300 letters, *fully printed in one minute!*

In this truly wonderful machine, the electric current is transmitted by a revolving cylinder of steel, which makes and breaks contact twenty-eight times in each revolution with one terminal of a voltaic battery. Each letter shown or printed requires a certain number of contacts and breaks; thus, for A. 1, for B. 2, C. 3, and so on. The revolving cylinder, starting from —— or Zero, is stopped accordingly by its cogs being caught by pins projecting from lettered keys, like those of a piano. Thus, if the cylinder commence revolving at A., and the sixth key F. be depressed, its pin will catch and stop a cog on the cylinder, when this has made and broken contact six times with the battery, and thus send three currents along the line, and cause three attrac-

tions and three liberations, or six vibrations, in the receiving magnet at the distant station.

The receiving arrangement is very peculiar, and consists of a vertical spiral of fine wire, about 3,000 yards long, wound round a brass tube ¾ inch in diameter, and 8 inches long.

Within this tube there slides a brass tube lined with tubes of soft iron in eight or ten separate pieces. These pieces are stationary, and become magnetic when a current passes in the coil. Within these tubes is suspended a brass rod, provided with a series of light concentric cones of soft iron, each cone corresponding with one of the external iron tubes. This brass rod is suspended from a horizontal wire stretched across and above a massive iron cylinder, in which the whole is enclosed. The use of this iron case is simply to give stability and protection to the delicate contrivances which it contains.

An electric current in the coil pulls down the suspended rod. On the current ceasing this ascends by the reaction of the horizontal wire. The play or stroke of the rod is not more than $\frac{1}{32}$th part of an inch, is, indeed, scarcely visible, yet this suffices to permit a jet of compressed air to gush alternately into either of two tubes from a small magazine of air into a small horizontal cylinder, in which it blows to and fro a highly-finished shuttle of polished steel. The hollow centre of this shuttle moves the stem of an escapement fork, alternately to the right and left, and thus every vibration of the rod and corresponding movement of the shuttle liberates a tooth of a horizontal wheel, on which the printing types are cut in bold relief. This wheel being kept automatically wound up by an internal spiral spring, a letter is shown by the recoil of the spring and rotatory progress of the type-wheel at every vibration, permitted and regulated by the electric current.

We have said that the condensed air is supplied by a pump. This is worked by a treadle or handle connected with a massive vertical fly-wheel placed under the table in a very solid iron frame, and on the axis of which a pair of bevel wheels and a vertical shaft give motion at the same time to a horizontal wheel, from which separate bands impart rapid rotation to the despatching cylinder, to an escapement cap, and to an eccentric arm,

which, when the type-wheel passes, passes the escapement and draws against the type a band of paper and an inked ribbon, also unrolled by the same mechanism.

To use this machine a man is employed to work the treadle and fly-wheel, while the signaller despatches or receives a message, which is printed off with a velocity and power quite amazing to persons who first witness its operation.

The workmanship of this telegraph is most creditable, combining the solidity of a steam-engine with the minute finish of the best clockwork. It is somewhat difficult to adjust it correctly, but, once arranged and securely screwed to a firm floor, it is evidently but little liable to derangement.

The use of this machine can be learned in a day. Its messages can be transmitted at once in duplicate or triplicate, or transferred instantly to stone for multiplication of copies. To guide the receiving clerk the letter telegraphed, painted on an ebony wheel, is seen for an instant at a square aperture above the type-wheel. The receiver thus detects an error of spelling in the message. When this happens he touches a key which breaks the circuit. This is at once known at the despatch station. Both operators, by pressing a spring, bring their telegraphs to zero, or the — -, and then start off again. This adjustment is readily effected in THREE *seconds* only.

These telegraphs cost £108 each in America. We are happy to add that while these pages are passing through the press, the Court of Directors have ordered eight such instruments to be procured for use on their Indian lines.

The only other telegraph used in America is "Bain's Chemical Marker." This, by means of prepared paper and an iron point, gives blue marks by the *distant* current directly on a horizontal disc, without the interposition of a local magnet. The marks consist of dots and lines, and are made in a close spiral line. The battery currents are transmitted at the distant station by a contact key, one touch of which gives a dot, while a more prolonged contact gives a line. By a very ingenious apparatus, Mr. Bain is enabled to prepare or compose the mes-

sage to be telegraphed by punching holes and spaces in a band of paper. This is made to pass with great speed over a brass roller, while a steel spring, pressing above it, enters each hole and space, thus establishing contact with the brass, and transmitting the current at each contact.

By this "*fast method,*" as it is termed, in America, it has been proved unequivocally that over one hundred words may be telegraphed or recorded in one minute, and by one wire.

In an experiment witnessed by the writer, the horizontal disc revolved at the rate of 16 times in a minute, and each revolution recorded 35 distinct and accurate groups of marks, each group representing a letter. This is equivalent to seven words in a revolution, or 112 words in a minute.

These 112 words were delivered through a punched paper band, which was found to measure 76 feet 3 inches.

The punching machine was found to prepare a message at the rate of 50 letters (each of four marks) in one minute at its maximum speed. This is no more than *ten words,* so that eleven compositors would be required to prepare in one minute the message which could be transmitted and recorded in that time by a single wire.

Again, the record of one minute's work is not decypherable in less than ten minutes by the most practised reader.

The strong current of natural electricity always flowing in our north and south lines in India would very much interfere with the adoption of this method of direct chemical printing. It was very extensively used in America, until a recent decision of the Supreme Court of New York, which declares Bain's patent to be an infringement of those of Morse, and has thus excluded it from the lines on which it was formerly used, in length 2,012 miles. In England these patents were, several years ago, purchased by the old Electric Telegraph Company, and the plan is employed in a few of their offices in the modified form described at page 134.

There is no other instrument at present in actual use which demands notice here except a revolving pointer and lettering telegraph, by Kramer, of Halberstadt, which is employed on

some of the Prussian railways. This is a modification of a most elaborate apparatus invented by M. Siemens, which attracted much attention four years ago in England and Prussia, but the use of which has been abandoned in favour of Morse's instruments, manufactured by M. Siemens, and bearing his name on the maker's plate.

M. Dujardin, of Lisle, has invented a *recording* telegraph, in which induced currents are employed to cause the repulsion of a small steel magnet carrying a silver pen, the point of which, on each repulsion, rises through a cistern of ink, and marks a dot or line spirally on a cylinder covered with paper, moved by clock-work above the pen.

The mechanism of this instrument is very ingenious. A pair have been purchased for £31 10s. for deposit in our Museum, and trial on our lines.

Copying Telegraphs.

In 1843, Mr. Bain proposed and patented a plan for *copying* by chemical marks, in *fac-simile*, any message, whether printed or written, the *fac-simile* being obtained at the distant station by chemical marks, and in dotted letters.

The machine consisted essentially of two revolving vertical cylinders, one at each station, ascending on a screw centre, and made to rotate at precisely the same speed, and at great velocity, by clock-work, regulated by pendulums. By writing the message on one cylinder in a non-conducting ink, on a metallic surface, and placing prepared paper on the other cylinder, the successive contacts and interruptions with the battery at one end were depicted by equivalent blue marks and blanks at the distant station, on the corresponding cylinder, by means of an iron pen touching this as it revolved, and communicating the electric current to prepared paper.

The plan never came into practical use, nor can the writer ascertain that it was ever even tried on any line.

In 1848, Mr. F. C. Bakewell, of Hampstead, also patented a copying telegraph on the same principle as Mr. Bain's, using nearly the same mechanism and the same chemical reagents,

but placing the cylinders horizontally instead of vertically, and causing the pen to move on a screw instead of the ascending motion of the cylinder, in the direction of its own axis.

Mr. Bakewell states that he has made a successful trial of his telegraph on the London and Brighton line. He prefers to use *two* wires, and with these he states he can copy 200 letters, or 40 words, in one minute. With one wire he undertakes to copy 100 letters, or 20 words, in the same time. In two experiments witnessed by the writer at Hampstead and at Warley the results were unsatisfactory.

It is believed generally that the inventions of Bain and Bakewell have proved unmanageable through the practical difficulty of keeping the separate cylinders in rapid rotation at exactly the same speed.

The writer believes this difficulty has been overcome by experiments he has just completed, and by which, by totally different mechanism and reagents, copying may be accomplished at an average speed of 20 words per minute by the use of one wire.

By the machine he has contrived, a letter or despatch, written in a large bold hand, in any language or character, is made to reappear in *fac-simile* in a permanent form on paper at the distant station. The mechanism by which this is effected is very simple and cheap,* and its use may be learned in a few minutes. Should this telegraph prove efficient on trial on the Indian lines, it will prove a valuable auxiliary to the needle instruments or American printer, by its affording the means of transmitting actual signatures and despatches in any language and character, or in symbolic cyphers of any shape, such as Egyptian hieroglyphics or Assyrian arrow-heads, for purposes of absolutely secret correspondence.

* Each machine may be made for £20.

PART V.

MISCELLANEOUS DETAILS.

ON THE CROSSING OF RIVERS BY MASTS AND SUSPENDED WIRES.

Rivers under 1,200 feet in breadth are to be crossed in this manner in all cases where this is practicable with reference to the height of the masts of the vessels passing under the line at the highest level in the rainy season.

It being impracticable to give precise rules applicable to each case, it will best fulfil the object of these pages to give an exact description of some remarkable river crossings effected in this manner in Europe.

We are indebted to Mr. H. V. Physick for the following details of the construction of the telegraph masts at Norwich.

The river is but 62 feet broad at high water, and then nearly level with its banks.

The masts, one on each bank, each of two spars, are 150 feet apart, and 100 feet above ground. The lower mast is 1 foot in diameter, 70 feet above ground, into which it penetrates 10 feet, and is stepped in a buried frame of two beams, crossed at a right angle, each 20ft. long, 6 inches square, the ends connected by four timber pieces strengthened at the angles by wrought iron straps and bolts. There are four timber strutts, each 12 feet long, one from each end of the cross piece, bolted to the mast, 2 feet below the ground. For the attachment of the stays there are 4 piles at equal distances, each 8 feet from the mast, 1 foot square, 12 feet long, shod with iron, and provided with iron caps and bolts. A stay of 1 inch iron rope leads from the top of the lower mast to each of these piles.

The top mast is 36 feet long, and 30 feet above the lower mast. The compound mast being 100 feet above the ground.

A cross stay of iron wire rope runs from mast to mast, 7 feet

below the top. Two stays, also of iron wire rope, lead from the same part of the mast to two piles 60 feet from the lower mast, and of the same dimensions as the other piles. The topmast is secured by 4 stays of iron wire rope, attached to cross trees in the usual mode of mast rigging.

A spindle and vane, serving also as the point of a lightning conductor of iron rope, completes the mast.

The telegraph conductors are 6 wires of No. 8 galvanised iron of the best kind. They are led through brown stone ware insulators attached to the mast at its highest part and above the stays. The wires are strained tight and led, each set, to a telegraph post 100 feet from the mast, and 35 high. From these posts the wires join the lines at each side.

Instead of the expensive and troublesome plan of framing for the underground work above described, it will be far better in India to employ the screw piles, 6 feet long, of which a sufficient supply has been provided.* These piles will carry a lower mast 35 to 40 feet high. Four of the ordinary small piles, 3 feet long, are first screwed into the ground each at 20 feet from the spot where the mast is to be erected. The mast fitted in its pile is raised into its position and steadied, tent pole fashion, by 4 rope guys lashed as required to a short spar in the smaller pile; 4 loops of iron wire on an iron plate fitting loosely on a pin in the mast, serve for the attachment of the guys, and keep the mast perpendicular while it is screwed into its place. This is effected by lashing a strong spar, by its middle, to the top of the pile, by a piece of chain, and a party of five men at each end man this spar, capstan manner. The screwing is easily accomplished in a stiff clay, sandy, or light gravelly soil, in five minutes. Four iron rope or rod iron jointed guys should then be permanently attached to screw piles of the 3 feet pattern planted obliquely in the ground. Each pile has a short wrought iron link for the attachment of the guy, and each guy has a tightening screw to regulate its tension.

A lofty mast erected in this manner forms the conspicuous flagstaff in the magnificent premises of Messrs. Ransome and

* These piles weigh 5 cwt. each, price £2 5s. for casting, with £1 for patent right, or £3 5s. each pile.

Simms, of Ipswich, where the screw piles for the Indian telegraph are manufactured.*

TELEGRAPH MASTS FOR THE CROSSING OF THE ELBE, NEAR HAMBURGH.

For the annexed details of this very remarkable crossing we are indebted to Mr. Tupper and to Mr. C. Gerk, the engineer of the line.

For rivers averaging 1,500 feet in breadth M. Gerk advises the use of masts strongly and substantially built, and from 30 to 40 feet higher than the highest masts of the vessels which have to pass below. This is necessary to allow for a deflection of $\frac{1}{50}$ in the wire, which, when of the very best description, can be strained no tighter, without great risk of fracture by storms, or by the weight of icicles in northern climates.

Five masts, such as we proceed to describe, have been erected in 1848 for the crossing of both arms of the Elbe.

Each mast penetrates 10 feet in the ground, and is there wedged down between strong cross beams, and the whole covered with heavy stones or concrete. About 16 feet from the end of each beam a pile is driven deeply and obliquely into the earth for the attachment of the stays, which are to be iron rods, 1 inch diameter below, ¾ inch in the middle, and ½ inch at top. These stays lead from the piles to the top of the lower mast, where they are attached to a wrought iron collar with four eye-bolts and rings. At 9 feet from the ground each stay is provided with a straining screw by which it is tightened to the required degree.

The masts described and figured by M. Gerk are 180 feet high, in several pieces bound together by wrought iron rings, 2 feet in diameter at the ground, tapering to 4 inches at the top. The first set of cross trees is at 70 feet from the ground. 4 beams, each of 36 feet long, are laid cross tree fashion at the surface of the ground, the mast in the centre; from each end of

* The order given of Messrs. Ransome and Simms is for 45,000 piles, each 3 feet long, 76 pounds weight; cost, patent claim included, 6s. each. 200 such piles are finished daily.

these beams a prop is bolted to the mast at 25 feet above the ground, and stays lead from the mast at 70 feet high.

The first cross-trees for the support of the shrouds, are four oak pieces, each 18 feet long. The second cross trees are 8 feet long, and are attached to the mast 150 feet from the ground. Above this point the spar rises 30 feet, and carries a wrought iron cap and pin with a porcelain or stone ware insulator of the Prussian pattern, figured at page 53.

Mr. Gerk employs a compound wire of 3 strands of No. 19 best charcoal iron, twisted together. According to his own experiments wire of this gauge withstands strains, storms, and casual pressure better than any other kind.*

Mr. Gerk erects the wire in the following manner:—

The wire is held ready wound on a reel, like that which ropemakers use, mounted on an axle, so as to let the wire run freely off.

The man who ascends the mast winds the end round his left arm in a knot, taking care that in drawing it after him it all runs free, especially of the backstays. When he reaches the top, he draws the end through the lignum vitæ sheave which is placed there, and either takes it with him below, or else fastens it at once by means of brass double screws to the other end of the conducting wire, which ascends from the last bottom peg, or out of the ground. In the latter case the point of connection will be in the first or second cross tree. As soon as this is done, two men, holding the reel by means of the staff on which it is centred, get into the boat which is lying ready, and a third, or the man on the mast, takes care that the wire runs freely off during the passage over to the other side. If the river is broad, and there is a chance of ships passing by, the wire, of which there must be at least 400 feet over length, is allowed to run free in the water, whilst the person who remained behind at the first mast holds fast, until all is so far in order by the other mast that the fixing-on can take place. But if the river is narrow, and there is no danger of ships passing by, the wire should be held as long as possible above the water, because a possible entangle-

* No. 19 wire, best charcoal galvanised, 1 cwt. contains 7,000 yards. [illegible] measures 22 feet [illegible] inches. Price per ton, £51 10s.

ment in the bed of the river will thus be avoided. As soon as the other bank is reached, about twice the length of the mast is let run off the roller, or, if there is more on, the necessary quantity must be drawn out of the river. To avoid risk of the wire breaking, two men go back in the boat, and, while one rows, the other lets the wire glide through his hands, in order to lift it from the ground.

If all is so far arranged, the mast-climber commences in the same manner as before to ascend with the end of the wire, in doing which he, as well as those below, ought to take care that the wire runs free, and especially that it does not hook behind the eyes of the backstays. As soon as the end is brought through the sheave, the man descends with it to the next cross tree, binds a weight on and lets it glide down to the man who is standing on the bottom cross tree, who takes hold of the wire and removes the weight. A strong iron pin must be fixed in a sloping direction to the under cross tree, in such a manner that the conducting wire may touch no other substance, and particularly no piece of metal. The iron pin is covered with an insulating cap, round which the man below lays the wire, whilst the one above climbs up as high as he can, and whilst he lays his breast against the top of the mast, stretches out his arms as far as he can, and draws to him the wire, unhindered by friction of any kind, out of the water or through the air; whilst the man below draws to him the wire thus gained, lays it round the insulator, and holds it tight, to prevent its sliding back again. If the wire is now so tight in its stretch across the stream that the man above cannot pull it further in with his hands, he fixes a vice to it as far out as possible, with flat teeth, and pulls in the wire as far as it will go without breaking. The proper measure is naturally the height of the ships which have to pass under with the highest high water, where a tide exists. If the wire has now its proper stretch, the man below wraps the same several times round the insulator, nips the end which hangs over pretty long off, and makes the connection to the general line.

The most remarkable masts hitherto constructed for telegraph purposes are those at each side of the Hudson river

means of which a wire, nearly a mile in length, has been extended from New York to the New Jersey shore. The masts are 300 feet high, and are stated to have cost 10,000 dollars. = £2,083. No detailed description of these masts has been published.

At pages 48 and 54 are noticed the instances of great spans of wire which are observed in the city lines in Paris, and in those over Mont Cenis and between Arquata to Genoa. In all these instances the wire employed is No 8, best charcoal iron, galvanised.

With reference to the length of span in telegraphic construction, the following table will be found to afford useful information :—

PARTICULARS OF NO. OF FEET PER 1-LB.; GAUGE AND LENGTH PER CWT. OF WIRE, FROM NO. 1 TO 20, GALVANISED.

	No. of feet per lb. Ft. in.	Gauge.	Yards per cwt. about	
No. 1	4.3	$\frac{5}{16}$	140	galvanised
2	5	$\frac{9}{32}$	170	,,
3	6	$\frac{1}{4}$	210	,,
4	7	$\frac{15}{64}$	240	,,
5	8	$\frac{14}{64}$	275	,,
6	$9\frac{1}{2}$	$\frac{13}{64}$	320	,,
7	12	$\frac{3}{16}$	400	,,
8	$13\frac{1}{2}$	$\frac{11}{64}$	450	,,
9	$16\frac{1}{2}$	$\frac{10}{64}$	550	,,
10	$21\frac{1}{2}$	$\frac{9}{64}$	730	,,
11	28	$\frac{1}{8}$	950	,,
12	33	$\frac{9}{80}$	1,150	,,
13	41	$\frac{1}{10}$	1,420	,,
14	55	$\frac{7}{80}$	1,900	,,
15	66	$\frac{6}{80}$	2,300	,,
16	90	$\frac{1}{16}$	3,100	,,
17	10.7		4,000	,,
18	16.2		5,200	,,
19	22.2		7,000	,,
20	33.1		10,500	,,

For these details we are indebted to Messrs. Tupper and Carr, Mansion-house-place, London.

GALVANIZATION OF IRON.

The iron is first prepared to receive the layer of zinc to be united to it. This is done in the following manner:—The iron is placed for five or six minutes in a mixture of one part muriatic acid to six of water. It is then taken out and dried in a furnace, heated to a dull red. When the iron has attained this heat it is again taken out and allowed to dry in the air. The scales of oxyde are removed by percussion. Any black spots which remain on the surface are separated by allowing the iron to remain ten or twelve hours in water, slightly acidulated with some fermented bran which has been steeped in the fluid for eight or ten days. The rods are next agitated in water containing a few hundredth parts of sulphuric acid. This done they are finally placed in water, and rubbed with sand and tow, after which they may be kept in water for use. Before immersing the iron in the zinc bath it is necessary to dry it. Messrs. Morewood and Rogers propose effecting this in an atmosphere of vapour, from which the air is excluded as completely as possible. This they accomplish by heating the articles in an iron case, the bottom of which is covered about three inches deep with sal ammoniac. The vapour of the salt drives out the air. The temperature must be gradually raised, since the object is merely to fill the case with the vapour of sal ammoniac. To coat the iron with zinc it is simply immersed in a zinc bath, after having been prepared as above.

The process of thus covering certain metals with zinc was well described by Malouin in 1742 (*Memoires Annexés a l'Histoire de l'Academie Royale des Sciences*, 1742, p. 110).

The zinc employed should be quite pure; and if earthen vessels be used for the bath, they should be enclosed in iron or cast metal casings, and the intervals between the two filled with fine sand or lead.

If metal baths are used, an alloy of iron and zinc is formed,

which perforates the metal in a few days and renders the bath useless.

The baths are heated with coke or coal; and the zinc is preserved from oxidation by covering it with a layer of sal ammoniac, rosin, or carbonate of soda. The time of leaving the iron in the bath is short; but it can only be learned by practice. As soon as it is thought that the galvanization is effected, the object is withdrawn from the bath and thrown into water in order that the sudden change of temperature may remove any excess of zinc. Any prominences are removed with a blunt rasp, and the metal is then rubbed with pumice stone or sand.

Finally, the process is completed by rubbing the surfaces with moistened sand, and then with a rag moistened with a solution of sal ammoniac.

The process of zincing is much facilitated by previously giving the iron a coating of tin. To effect this the iron, cleaned and brightened as above described, is immersed in a weak solution of chloride of tin, two quarts concentrated solution to 120 gallons of water, in a wooden tank. This quantity is enough for one ton of sheet iron. The chloride of tin is prepared by dissolving granulated tin in muriatic acid. Over every layer of iron is placed a layer of granulated zinc, on this more iron, then a second layer of zinc, and so on. In about two hours the iron will be found coated with an adherent layer of metallic tin deposited by voltaic action.

PREPARATION OF SUNDRY ARTICLES REQUIRED ON TELEGRAPH LINES.

Nitric Acid.

Where sulphuric acid can be procured, nitric acid is easily prepared by distillation from iron, earthenware, or glass retorts, by heating together equal parts, by weight, of good saltpetre and ordinary sulphuric acid, and condensing the vapours in glass or earthenware vessels.

If sulphuric acid be not obtainable, alum (native name, *Phitkari*) can be procured in nearly every bazaar. 2 parts of

alum to 1 saltpetre, by weight, heated to dull redness in an iron or earthenware tubular retort, give off abundant vapours of nitric acid, which can be condensed in the same manner as when sulphuric acid is employed.

A smart native blacksmith will be found able to weld up sheet-iron into tubular retorts for this purpose. The bazaar potters readily adjust the common earthenware vessels of the country, so as to enable any person of common smartness to make the acid for himself.

Muriatic acid is prepared in the same manner, only substituting common salt for the saltpetre, and receiving the vapours in a vessel half filled with water.

For the purposes for which these acids are employed in telegraph offices, purity or uniformity of strength are of no importance.

Sulphate of Copper.

If sulphuric acid be available, this salt is easily prepared by heating pieces of copper to redness under a current of air, so as to cause scales of oxide to form. These scales are a mixture of metallic copper and the black oxide. This is dissolved by warm dilute sulphuric acid, 1 part acid, 3 water, and forms a blue solution. This, evaporated till a skin forms on the surface, gives fine crystals of sulphate of copper.

This salt (*Neel Tutya*, Bengal) is also made without the use of acids, in the following manner:—

Take pieces of sheet copper and heat these to low redness. In this state rub them with sticks of sulphur. A black compound, the sulphuret of copper, is formed, containing 16 sulphur to 32 copper in every 48 parts.

When cool, rub this in a stone mortar, or on a curry-stone, with half its bulk of clean sand; place the mixture on common earthen saucers (*Sanuck*, Bengal), and heat gently over a charcoal fire, the air playing on the surface. When the colour changes from black to grey, remove from the fire and allow the mixture to cool. If it be now washed with warm water, the solution will yield abundant crystals of sulphate of copper.

roasting does not remove all the copper, and the mixture, after washing with water, may be heated and washed three or four times in succession, till the washings cease to yield the copper salt.

Fused Chloride of Silver.

Dissolve common rupee silver in its own weight of nitric acid, mixed with an equal bulk of rain water. The black powder remaining after the solution is gold, and should be collected. The native goldsmiths will refine and melt it. Every 32 rupees contain about a rupee's worth of gold.

To the solution, diluted with four times its bulk of water, add a strong solution of common salt, as long as a white, curdy, solid matter is formed. If this be done in a large stoppered bottle, and then be well shaken, the solid parts coagulate together, and the liquid may be poured off and thrown away. Water should be added, and several washings performed, till the liquor comes off colourless and tasteless. The curdy matter is then placed on a smooth dry tile, in a mass half-an-inch thick; the tile absorbs the moisture, and the drying may be completed on a plate placed over a saucepan of boiling water.

This chloride of silver, heated to low redness in a platinum or silver cup, melts like wax, and can be cast into tablets, the singular electrical properties of which have been described in this Manual at page 14.

The Chloride of Zinc

is best made by dissolving pieces of zinc in dilute muriatic acid, and evaporating the solution to dryness. The chloride is of a pasty nature, readily attracts moisture from the air, and is to be kept in well-stoppered bottles.

This chloride of zinc, dissolved in the smallest possible quantity of water, is used in the soldering of copper wire joints, in the manner described at page 64.

Carbon Cylinders for Batteries.

Good coke is reduced to coarse powder, and made into a thick paste with a strong solution of sugar. This is rammed

into an iron mould, 6 inches long, $1\frac{1}{2}$ inches square, by blows of an iron rammer, and the ends of the mould are closed with fine clay or bone-ash, and the whole heated to a white heat in a forge. On cooling, the carbon is found in hard prisms, which ring like metal when struck by a hard body. In this state this substance is used for the Bunsen batteries, described at page 12.

EXPERIMENTS IN PICKLING OF TIMBER IN ARSENIC, BY MR. R. L. BRUNTON.

With reference to the instructions at pages 85 and 86, on the pickling of timber used as protectors in the subterranean lines, the following experiments, kindly made by Mr. Brunton, at the writer's request, are deserving of attentive consideration :—

Experiments with three pieces of deal, each measuring 1 inch by $2\frac{1}{2}$ inches by 18 inches, and numbered 1, 2, and 3. These pieces were cut from an ordinary deal board, which had been for some time exposed to the weather.

Desiccation.—Nos. 2 and 3 were placed near a steam-boiler for fifteen hours; a thermometer in the same position indicated from 120 deg. to 130 deg. Fah., and the desiccation was aided by a constant current of dry air. These pieces lost by drying as follows :—No. 2, 12.3 per cent.; No. 3, 12.6 per cent. It is probable the difference of 0.3 per cent. in the loss of moisture arose from the pieces not being equally dry or wet previous to desiccation, rather than from any variation in the process

Immersion.—A bath was prepared by boiling an excess of arsenious acid in distilled water, and when the solution had cooled down to about 90 deg. Fah., Nos. 1, 2, and 3 were placed in it, Nos. 2 and 3 being warm from the drying process. In this bath Nos. 1 and 2 remained for twenty-four hours, No. 3 for forty-four hours.

Results.—No. 1 having been immersed without any a[illegible] desiccation, only absorbed about 13.72 per cent. of the ar[illegible] solution, being about 16 grains of arsenious acid to th[illegible] foot of wood. A strip from the exterior of No. 1 gave [illegible]

precipitate of solution of arsenic when tested in an acid solution of sulphuretted hydrogen. Strips from the interior of No. 1 gave no trace whatever of having been reached by the solution.

No. 2 during its immersion had absorbed 33.57 per cent. of the solution, being by calculation about 50 grains of the arsenic to the foot of wood.

No. 3, although immersed for twenty hours longer than No. 2, had only taken up about .4 per cent. additional of solution.

Pieces from the exterior of Nos. 2 and 3 gave most abundant precipitates of sulphuret of arsenic, and small strips from portions of the wood, at the greatest distance from the outside, gave the most decided evidence of having been reached by the arsenical solution.

PRECAUTIONS TO BE ADOPTED PREVIOUS TO AND DURING HURRICANES.

In the introductory remarks in the first page we adverted to the measures of precaution to be adopted during the violent gales by which India is frequently visited.

An instance is given at page 57, of the occurrence of one of these disastrous hurricanes, on the 14th of May, 1852. On the 23rd and 24th of October the previous year a similar, but less destructive, storm took place. Each office being provided with a barometer, the fluctuations of which are noted four times daily, the approaching storm was in both these instances foretold by a remarkable fall in the mercurial column. Orders were forthwith telegraphed to each of the out-stations to entertain extra men to patrol the lines, chiefly in the vicinity of the villages, and each man was provided with a few feet of copper wire, pincers, a hammer and file, in order to establish a temporary junction in case of any accident to the line. The best men to be employed under such circumstances are the native *gramies* (thatchers and bamboo workers), who are generally bold, hard-working fellows, not easily driven from their duty by rough weather. Double the usual day's pay may be given fairly on such occasions.

During the hurricane of the 23rd and 24th October all hands remained on duty day and night, and bulletins of the state of the shipping at the out-stations were posted every ten minutes. No interruption whatever occurred. In the storm of the 14th of May the central station-house at Bishtapore was blown down at midnight; but the boys on duty, with the aid of the native thatchers, got up a temporary shelter. The broken wires were joined, and signalling was resumed in less than half an hour.

Assuming that all the arrangements, so minutely prescribed as safe-guards against lightning, have been faithfully carried out, the occurrence of thunder-storms must never be allowed to interrupt the current duties of the offices. The signaller on duty, like a soldier on guard, or a seaman on his watch, must take his place at his instrument as usual. After a little experience he acquires the habit of observing, without alarm, the effects of lightning on the apparatus he is using; he soon appreciates the perfect protection afforded by the precautions employed, and business thus proceeds without interruption during the most violent commotions of the atmosphere.

Were a different system permitted—were the signallers allowed to leave their instruments during thunder-storms, or the occurrence of bad weather of any kind admitted as an excuse for cessation of correspondence—it would be found totally impracticable to maintain regular communications on the Indian lines during several months in each year.

Storms are often confined to narrow circles, and travel in very eccentric paths. It frequently happens that a heavy thunder storm with copious rain visits Barrackpore, and is scarcely felt at Calcutta, but fourteen miles distant. In March, 1852, a remarkable instance of this kind took place in Calcutta. While the whole European community were enjoying their evening drive and promenade by the river side, a furious squall burst upon them from the south-west. Several large ships were blown on their beam ends or torn from their moorings. Great loss of life occurred; trees were torn up and carriages upset on the course. In the midst of this turmoil (the doors and windows of the Calcutta station were blown to pieces) the telegraph there reported quietly, "serene weather at Moyapore — sultry and

overcast at Diamond Harbour, and the *Rattler* steamer passing Kedgeree with a fair breeze from the south, and all sail set." The distances of these stations from Calcutta are respectively 14, 30, and 60 miles in a straight line.

On the completion of the long lines it may be fairly assumed that these will be visited by storms, in some locality or other, every hour of the day, from March to October. Accordingly, too much importance can scarcely be attached to the steady maintenance of office duties during such local visitations, as the only means of preventing the interruption of correspondence in the whole system.

CHARGES FOR DESPATCHES.

English.

For all distances under 100 miles. 20 words, including address and signature, 2s. 6d.; over 100 miles, 20 words, 5s.; half the above rates for 10 words over, or a charge of 3d. per word at option of sender. Messages sent from stations on foot, 6d first half mile, and 6d. per mile additional. By cab or horse, 1s. first half mile, and 1s. per mile additional.

"The public are informed that, in order to provide against mistakes in the transmission of messages by the electric telegraph, every message of consequence ought to be REPEATED by being sent back from the station at which it is to be received to the station from which it is originally sent. Half the usual price for transmission will be charged for repeating the message."—*Official Printed Forms, received from Telegraph Company, August*, 1852.

South Eastern Lines.

Charges as above, with same stipulation as to *repetition*; and company declare themselves not responsible for mistakes in the transmission of a message, even if repeated, nor for delay in transmission or delivery, or for non-transmission or non-delivery of any message, whether repeated or unrepeated.—*Official Printed Forms, August*, 1852.

While these pages are passing through the press, the prospectus has appeared of a new company, designated the United Kingdom Electric Telegraph Company, who intend, in the lines they propose to construct, to charge but one penny per word, irrespective of distance. They also promise to let out wires on hire for the exclusive use of firms or individuals, at a yearly

rent of £2 to £3 per mile. The lines of thi company are to be underground.

American Tariffs.

Line	From	To	Distance	Words	Charge.			
			Miles.		Dol. c.		s.	d.
Morse Line.	New York	......Pittsburgh........	400	10	0 60	=	2	6
	New York	......Cincinnati........	780	10	0 75	=	3	1½
	New York	......Boston...........	240	10	0 20	=	0	10
Bain Line.	„	......Buffalo...........	500	10	0 43	=	1	9½
	„	......Boston...........		10	0 20	=	0	10
	„	......Baltimore........		10	0 50	=	2	1
House Line.	„	......Buffalo...........	500	10	0 40	=	1	8
	„	......Halifax, N.S.	1,090	10	1 55	=	6	10½
	„	......Montreal, Canada.		10	0 85	=	3	6½
	„	......New Orleans.....	1,966	10	2 40	=	10	0
	„	......Quebec		10	1 10	=	4	7

General average charge in United States, 20 words, 500 miles, 1 dollar = 4s. 2d = 2 rupees. Address is sent free.

FOR PRESS.—Reports of Congress from Washington to New York, 5 cents = 2½d., per word, for each of first 300 words; one-third less for all words over 500 and under 1,000, and two-thirds reduction for all words over 1,000 to any number.

New York to Boston, Press Charges, ½d. per word.

French Tariff, 1852.

PARIS to	Distance.		Words									Engl mon 20 Words.
			1 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90	91 to 100	
	Mile.	Kil.*	francs.	francs	francs.	francs.	francs.	francs.	francs.	francs.	francs.	s. d
Amiens .	92	147	4 80	6 00	7 20	8 40	9 60	10 80	12 00	13 20	14 40	4 0
Boulogne	170	272	6 36	7 95	9 54	11 13	12 72	14 31	15 90	17 49	19 08	5 3
Calais . . .	236	378	7 56	9 45	11 34	13 23	15 12	17 01	18 90	20 79	22 68	6 3
Lyons . .	317½	508	9 12	11 40	13 68	15 96	18 24	20 52	22 80	25 08	27 36	7 7

* One kilometre is ⅝ths of an English mile.

Belgian Tariff.

Distances.	Words. 1 to 20	21 to 50	51 to 100
	s. d.	s. d.	s. d.
1 kilometre = ⅝ English mile, for 75 kilometres = 46⅞ miles	2 1	4 2	6 3
From 47 to 125 miles	4 2	8 4	12 6
Above 125 miles	6 3	12 6	18 9

Submarine Telegraph Company's Charges.

London to	Words. 20.	21 to 30	31 to 40	41 to 40.	51 to 60.	61 to 70	71 to 80.	81 to 90.	91 to 100.
	£ s. d	£ s d.	£ s. d.	£ s. d.	£ s. d	£ s. d.	£ s. d.	£ s d.	£ s d.
Amsterdam...	1 5 0	1 17 6	2 0 6	2 3 6	2 14 6	2 17 6	3 0 6	3 4 6	3 7 6
Berlin	1 13 0	2 13 0	2 16 6	2 19 6	3 18 6	4 1 6	4 4 6	4 7 6	4 10 6
Bordeaux	1 4 3	1 10 6	1 15 6	2 0 6	2 5 6	2 10 6	2 15 6	3 0 6	3 5 6
Brussels	1 1 0	1 9 6	1 12 6	1 15 6	2 2 6	2 5 6	2 8 6	2 11 6	2 14 6
Calais	0 12 6	0 16 0	0 18 0	1 0 0	1 2 0	1 4 0	1 6 0	1 8 0	1 10 0
Frankfort	1 9 0	2 5 0	2 8 6	2 11 6	3 6 6	3 9 6	3 12 6	3 15 6	3 18 6
Florence	2 5 6	3 17 6	4 1 0	4 4 6	5 15 6	5 18 6	6 1 6	6 [illegible] 0	6 8 6
Hamburgh....	1 11 0	2 9 0	2 12 6	2 15 6	3 12 6	3 15 6	3 18 6	4 1 6	4 4 6
Kehl-Strasburg	1 13 0	2 13 0	2 16 6	2 19 6	3 18 6	4 1 6	4 4 6	4 7 6	4 10 6
Marseilles	1 7 0	1 14 0	1 19 6	2 5 0	2 10 6	2 16 6	3 2 0	3 7 6	3 13 0
Milan	1 13 0	2 13 0	2 16 6	2 19 6	3 18 6	4 1 6	4 4 6	4 7 6	4 10 6
Paris..........	0 19 0	1 3 6	1 7 0	1 10 6	1 14 0	1 17 6	2 1 0	2 4 6	2 8 0
Trieste.........	1 15 0	2 17 0	3 0 6	3 3 6	4 4 6	4 7 6	4 10 6	4 13 6	4 16 6
Venice........	1 15 0	2 17 0	3 0 6	3 3 6	4 4 6	4 7 6	4 10 6	4 13 6	4 10 6
Vienna	1 15 0	2 17 0	3 0 6	3 3 6	4 4 6	4 7 6	4 10 6	4 13 6	4 16 6

"To prevent mistakes every message of consequence ought to be repeated. Double prices charged for repetition to or from France. Half price for repetition to or from other parts of Europe. The Company deny all responsibility for mistakes, delay, non-transmission, or non-delivery of any message from any cause whatever, even if message be repeated."—*Official Printed Form*, 1st January, 1858.

PAY, PENSIONS, &C., OF CLERKS AND MESSENGERS.

In England.

OLD ELECTRIC TELEGRAPH COMPANY.

In England.	Weekly sa £ s.	Monthly equivalent in rupees, say
1st Class	2 0	90
2nd *a.*	1 15	75
2nd *b.*	1 10	65
3rd	1 5	55
4th Assistant Clerks	1 0	43
5th Junior ditto	0 17	36
6th	0 14	30
7th	0 12	26
8th	0 10	22
9th	0 8	17

Messengers' wages, 5s. to 18s weekly. Pensions, none.

French Offices.

No one is employed under 20 years of age. Assistants are of 4 classes.

	Annual salary	Equivalent in rupees per month.
1st Class	£36	30
2nd „	48	40
3rd „	60	50
4th „	72	60

With pensions of one-sixth the salary after 30 years' service, and one thirtieth for every additional year. No assistant is permitted to hold any other employment.

Each signaller is on duty half of each day. Two are allowed for each telegraph. No alarms ever allowed. Offices open from 7 a.m. to 9 p.m. No night-work except by special order of Government.

American Offices.

Each office on an average employs four young men as clerks and signallers; in places of small note, one or two signallers only. The highest salary is 100 to 1200 dollars, say 2000 to 2400 rupees a year = 200 rupees per month. The messenger

boys, who earn from one penny to sixpence for each message they deliver, gradually acquire proficiency as signallers, and receive regular and higher wages as they become useful and trustworthy.

LAWS AFFECTING THE USE OF THE ELECTRIC TELEGRAPH IN ENGLAND, AMERICA, AND FRANCE.

The construction and use of the electric telegraph having fallen in England into the hands of private speculators, the Government merely retain the power of ordering all messages on her Majesty's service to take precedence of all other communications; and in times of civil commotion, or other public emergency, the Secretary of State can take exclusive possession of all lines and offices for the sole use of Government.

In case of wilful damage to their lines or offices, the companies have the ordinary remedy of indictment for misdemeanor. In accidental damage any magistrate has the summary power of assessing its value, and seizing the defendant's goods for the amount.—*9th Vict., cap.* xliv.

Penalties are inflicted for undue preference shown in the transmission of despatches. For neglect of duty on the part of signallers, a fine is inflicted of £20 for each offence. The law interferes little with reference to the maintenance of secresy, or prevention of illicit traffic in intelligence. The proprietors of the lines are allowed to deal with such irregularities as they best can, by fines and by dismissal from their employment.

In America, several of the States have passed stringent acts regulating telegraphic correspondence, although the lines are private property. The law of Pennsylvania subjects all persons employed in telegraph offices, who may be convicted of violation of secresy, or "in anywise impairing the value of any correspondence sent," to a fine of not less than 100 dollars (200 rupees), or imprisonment for six months, or both, according to the circumstances and aggravation of the offence.

For the protection and regulation of the telegraph in France, several laws have been passed by the Republican and Imperial Governments. We give a sufficient *précis* of these en-

actments, as published officially by the Telegraph Administration in Paris.

The National Assembly of France, on the 3rd July, 18th and 29th November, 1850, adopted the following law:—

1. All persons whose identity is established are allowed to correspond by the Government Electric Telegraph, and by the agency of the functionaries employed in the department.

2. Private correspondence is always subordinate to the necessities of Government service.

3. Despatches, legibly written, *in ordinary and intelligible language*, dated and signed by the senders, are, by them or their representatives, given to the director of the telegraph, and copied in full, with the address of the sender. This copy is authenticated and filed in the office.

Articles for newspapers and despatches on railway business are exempt from the copying rule.

3. The director of the telegraph may, on grounds of public order and morality, refuse to transmit a despatch. In case of dispute, reference is to be made in Paris to the Minister of the Interior; in the provinces, to the Prefect, Sub-Prefect, or other constituted authority.

On receipt of a despatch, the telegraph agent may withhold it under like circumstances and rules.

4. Private correspondence may be suspended by order of Government.

5. Any public functionary violating the secresy of correspondence is liable to the penalties prescribed in Art. 187 of the Penal Code, viz., imprisonment from three months to five years, fine of 100 to 500 francs, and total exclusion from public service.

6. The State incurs no responsibility whatever for private despatches.

7. Telegraphic despatches prepay a duty as follows:—

For 1 to 20 words, 3 francs, besides 12 centimes for every myriametre.

Above 20 words the tax is increased one-fourth for every ten words, or fraction of ten words in excess. The address, date, and signature are counted. Figures are valued as if spelled in

full. Every fraction of a myriametre counts as one myriametre. Night despatches, when transmitted, are charged one-half higher rates.

Subscriptions, at reduced rates, may be conceded for railway business.

By paying double rates individuals may have their messages repeated.

9. Besides the rates specified, there is a charge of 50 centimes (5d.) for each message delivered in the country towns, and 1 franc (10d.) in Paris.

10. Despatches are transmitted in the order of their inscription.

If the despatch exceeds 100 words, it may be kept back, and priority given to shorter messages, although of later inscription.

Despatches affecting the safety of passengers by railway trains in all cases take precedence of every other business.

A DECREE regulating the service of private correspondence by electric telegraph, dated 17th June, 1852, by the President of the French Republic, establishes as follows:—

1. The offices to be open daily at the hours fixed by the Minister of the Interior. The hours are posted at the office doors. The time of every office is that of the Observatory of Paris.

2. Proof of identity is essential, or knowledge by the director of the signature to the despatch. Identity may be proved by witnesses, passports, or other written evidence; signatures may be proved by prefects, sub-prefects, magistrates, notaries, mayors, commissaries of police, &c. &c.

3 to 7. Despatches must be written legibly in ordinary language, dated and signed, and no abbreviation. If the director sees reason to refuse transmission, he states the reason in writing on the despatch, which is returned to the person concerned.

The time of the despatch and of its arrival at its destination are entered in the office register.

8. If the line is free, a despatch is instantly forwarded; if the line be occupied, the message takes its turn.

9, 10, 11, regard the order in which stations correspond

successively with each other, half an hour being allotted to each in turn.

12. No despatch once lodged can be withdrawn, except by the same person who delivered it. No money is returned for a despatch so cancelled.

13 to 20 inclusive, affect the local deliveries of despatches.

20 to 24 determine the distances, the charges for compound words, family names, and addresses; prepayment for different charges.

25 orders that the sum paid for a despatch shall be returned in case of undue delay in delivery through interruption of the line, through mistakes by the signallers, or by delivery being prohibited by the authorities at the distant station.

26. The sender may pay for the answer, and make a deposit on this account of the charge for 20 words.

27 to 33 regulate the mode of keeping the office books and accounts—of paying into the local treasuries all sums received up to the 1st of each month.

34 prescribes the mode of adjusting accounts with Foreign Governments.

35, 36, and 37 subject the accounts of the telegraph department to the general financial authorities of the State.

By a Decree of the 27th December, 1851, by the President of the Republic, on the report of the Minister of the Interior:—

Art. 1, orders that no line of electric telegraph can be established or employed for the transmission of correspondence except by the Government, or on its authority.

Any person transmitting, without authority, signals from one place to another, whether by electric telegraph or any other way, is liable to imprisonment from a month to a year, and a fine of from 1,000 to 10,000 francs; and the Government may order the destruction of the apparatus and telegraphs employed.

2. Any one accidentally or involuntarily interrupting the correspondence of the electric telegraph, or injuring in any way the lines or apparatus, is liable to a fine of from 16 to 300 francs.

3. Any one wilfully causing such interruption, by injuring the lines or apparatus, is punishable by imprisonment from three months to two years, and a fine of 100 to 1,000 francs.

4. A fine of 1,000 to 5,000 francs may be inflicted on persons convicted of injury to telegraph lines or instruments, or forcible intrusion into offices, or of using violence or menaces to signallers, or interfering with repairs of lines, during periods of insurrectionary movements.

6, 7, and 8 regulate the obligations of railway officers respecting the telegraph lines.

9 gives power to remove trees or other impediments to construction or working of lines.

10 to 14. Written statements by telegraph officers, authenticated by police or magisterial authorities, to be received as evidence in all complaints; also rules are given for civil proceedings in all cases of crimes, contraventions, and recovery of damages.

Lastly. It is ordered, by a subsequent decree, that all telegraphic despatches, duly authenticated, are to be regarded as official and authoritative, and to have all the force and effect of public documents, signed by the functionaries at the distant station from whom the telegraph despatch proceeds.

APPENDICES.

APPENDIX No. 1.

STATISTICS OF SCREW PILE MANUFACTURE FOR THE EAST INDIA COMPANY.

The quantity required is 45,296; form as per drawing, page 38; weight, 76 lbs. each; price six shillings. Contracted for by Ransomes and Simms, Ipswich, to be executed in nine months.

About two months were occupied in experiments as to the best method of preparing patterns and producing the castings accurate and uniform, thus leaving about twenty-eight weeks for the execution of the contract, which would require their production at the rate of about 1,700 screws, 56 tons, weekly. The patterns are made of iron polished and bronzed in the same manner as gun barrels. The stalk of the pile pattern is in halves, of which when the moulding box is parted, one half remains in the bottom and the other is taken up in the top part. The screw part of the pattern is formed in 4 pieces, and the octagon head in 2 pieces, thus the pattern is made to consist of 8 pieces, each of which is separately removed, and a simple and ingenious contrivance is adopted for withdrawing those parts of the pattern forming the screw, by which, with a slight acquirement of sleight, they are wormed out of the sand without breaking the edges.

The boxes are specially adapted to the form of the castings. These are put together with turned pins in the lower box, fitting into holes bored in the upper one, all to one guage, so that each shall accurately fit every other.

To form the cores or hollow part of the pile, boxes with the exact form of the interior of the pile grooved in them are fitted with sand lightly rammed, and provision is made in them for leaving a free passage for the rapid expansion of the air when heated by the melted metal surrounding it.

If these passages should be imperfect so that the air did not

escape with sufficient rapidity, it would attempt to force its way through the liquid metal, and the casting would be imperfect and hollow.

The plant required to make this quantity in the time stated is 72 moulding boxes, 10 core boxes, 18 patterns, 4 trimming benches, each accommodating 3 trimmers.

The staff requisite: 36 moulders and assistants, 1 facing sand maker, 13 core makers, 12 trimmers, 3 ladle carriers for melted metal, 2 wheelers, 3 packers, 3 labourers to wait on the above.

APPENDIX No. 2.

LIST OF STORES FOR ONE MILE OF OVERGROUND LINE.

		Indian Maunds of 80 lbs.
Iron Rod—weight per mile, 10 cwt., in 4 pieces		14
Screw Piles—16, at 75 lbs.		15
Zinc for 4 joints	8 lbs.	
Caps, galvanised iron	16	
Oak Brackets	16	
Stoneware Insulators, in sets	32	
Cap Screws	16	
Insulator Hooks and Nuts, iron	32	
Spare Iron Rod for Lightning Conductors, 16 × 30	480 feet.	
Rosin for Cement	16 lbs.	
Sand, washed and dried	48 lbs.	
16 Posts of Teak, Saul, or Iron wood, 20 to 24 feet long.		
16 Bamboos, each 24 feet.		

LIST OF IMPLEMENTS REQUIRED FOR EACH WORKING PARTY FOR OVERGROUND LINE.

		Value.		
1 Moveable Straining Post, with Screw Pile (see p 43).				
1 Straightening Machine	(see p 31)	£18	0	0
2 Bracing Screws	(„ 44, 57)	11	0	0
2 Spanners and Nuts for ditto		1	5	0
5 Wrenches for Screwing Nuts		1	5	0
5 ditto for making Eyes	(see p. 32)	1	2	6
1 Chain Holdfast		0	12	0
3 Ingot Moulds	(see p. 32)	2	12	6
5 pair large Pliers		0	15	10
5 pair small ditto		0	10	0
5 eight-inch Ladles		0	12	6
5 four-inch ditto		0	5	0
		£37	19	6

Weight in case, 896 lbs; measurement, 57 cubic feet.

Besides these, each party will be provided with ordinary carpenters' and blacksmiths' tools, and gutta-percha tool chest.

CARPENTERS' AND GENERAL TOOLS REQUIRED FOR EACH WORKING PARTY FOR OVERGROUND WORK.

4 Spades (Kodālies).
4 Pickaxes.
4 Earth Rammers.
1 Measuring Tape Line or Chain, of 100 feet.
2 Hammers.
1 Pulley Block.
2 Adzes.
6 Cold Chisels.
2 Hand-saws.
1 Cross-cut.
2 Planes.
3 Augers: $\frac{1}{4}$-in. $\frac{1}{2}$-in; $\frac{3}{4}$-in.
1 dozen large Gimlets.
1 pair Pincers.
3 Plough Irons: $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$-in.
1 Two-foot Rule.
2 Tenon Saws: 16-in., 18-in.
$\frac{1}{4}$-in. and $\frac{1}{8}$-in. Round Planes.

CONTENTS OF TOOL CHEST FOR GUTTA-PERCHA JOINTS.

Blow-pipe, complete, with Stand, Spirit Lamp, and Joining Tools.
Furnace, with Spirit Lamp.
Gutta-percha Bottle for Chloride of Zinc; Funnel for filling Lamp.
Tin Bottle containing 1 quart of Wood Naphtha.
1 lb. Thin Copper Wire, on Spool $\frac{1}{4}$ lb. Solder.
3 lb. Thick Sheet Gutta-percha $\frac{1}{2}$ lb Thin ditto.
Small Hammer. 2 Knives. File.
2 pairs Pliers: 1 cutting, 1 flat nose. 1 pair Scissors.
Emery Paper and Ball of Cotton.
Mahogany Chest, complete, with handles, lock, and key.

Weight, 60 lb.; price, £4 10s.; from Gutta-percha Works, City Wharf-road, London.

APPENDIX No. 3.

RULES FOR THE MANAGEMENT OF THE ELECTRIC TELEGRAPH, BETWEEN CALCUTTA, DIAMOND HARBOUR, AND KEDGEREE, PASSED ON THE 18TH OF DECEMBER, 1851.

1. Until further orders, the service shall be conducted by the Superintendent, in direct communication with the Government of Bengal.

2. The Telegraph Stations shall be open continuously, day and night, throughout the year, for the receipt and transmission of correspondence.

3. The officers, named on the margin, are authorised to have their messages on public service conveyed, subject to *pro formâ* charge at the usual rates, taking precedence of all private communications. Other public Officers, having messages on public service to transmit, will apply to the Superintendent; or in emergent cases to one or other of the Officers above-named.

Secretaries and Under Secretaries to Government.
Superintendent of Marine and his Secretary.
Master Attendant & his Assistants.
Collector of Customs, Deputy Collector and Assistant.

4. All ordinary shipping intelligence is to be transmitted, in writing, hourly to the Superintendent of Marine and the Master Attendant. Important shipping intelligence is to be transmitted, immediately upon receipt, to the same Authorities.

5. Printed Reports of intelligence are to be issued at 10 a.m., 1 p.m., 4 p.m., and 7 p.m. These will be forwarded to the offices of the Authorities named on the margin, and to all Firms and Individuals who are Subscribers. Arrivals after 4 p.m. are to be notified specially in writing, to the Agents of the Vessels, if Subscribers, without extra charge, and to be posted outside the office in a conspicuous place.

Members of Government, Secretaries to Government, Private Secretaries to the Governor General and Deputy Governor of Bengal.
† Superintendent of Marine.
† Master Attendant.
† Register of Seamen.
Board of Revenue.
† Collector of Customs.
† Superintendent of Preventive Officers.
Military Board.
† Postmaster General
The Authorities marked thus (†) will be charged *pro formâ*, as registered Subscribers.
Officers not named in the above list, requiring on public service, particular information on occasions, should intimate to the Superintendent the information they require, which will be specially furnished to them, subject to *pro formâ* charge at the usual rate.

6. Special notice of the arrival of any specified Vessel is to be sent immediately to the residence or office of any person within Calcutta, requiring it, at a charge of four annas (6d.) in the case of a Subscriber, and one rupee (2s.) in the case of any other person.

7. In case of any irregularity, delay, or interruption in the transmission of messages, or the delivery of Notices or Reports, on public or private service, complaint should be made to the Superintendent.

8. Any Officer, Signaller, Clerk, or other person employed in the Telegraph

Stations, disclosing improperly the particulars or tenor of any message sent by Telegraph, whether on public or private service, shall be dismissed, forfeiting all arrears of salary; and shall be declared disqualified from serving Government in any capacity.

9. Messages will be transmitted at the following rates:—

To any Station on the Diamond Harbour line, at four annas for each word of not more than two syllables, and one anna for each additional syllable.

To any Station beyond the Hooghly, on the Kedgeree line, eight annas for each word of not more than two syllables, and two annas for each additional syllable.*

Messages will be delivered on board of Vessels at the River Stations, at a charge of eight annas for boat hire; and messages will be delivered to persons in Calcutta without charge for peon hire to Subscribers, and at a charge for peon hire of four annas to other persons. Messages will be delivered, at moderate distances beyond Calcutta, to all persons, at the necessary extra charge for Keranchy hire, in addition to four annas for peon hire.

10. Between sunset and sunrise the above charges will be doubled, and the Superintendent will be allowed, at his discretion, to divide the receipts on account of such night messages amongst the Signallers who receive and transmit the communication.

11. The transmission of messages gratuitously is prohibited on penalty of dismissal.

1. Vessels in distress.
2. Mail Steamers.
3. Public Service.
4. Private Service of Subscribers.
5. Shipping Business.
6. Private Service of Individuals and Firms, not Subscribers.

12. Messages will have precedence in the order noted in the margin.

13. Persons using the Telegraph are admitted into the outer room of the office; but no persons, whether public Officers or private individuals, will be admitted into the inner rooms. Visitors can be allowed access to the Signal room only by the special order of the Superintendent.

14.—No record or copy is to be kept of the nature or contents

* These high rates were assigned in order to prevent an inconvenient pressure of business on the first opening of the offices. The charges on the long lines will probably be assimilated to those in America.

Message received from Messrs A. B., for transmission to Diamond Harbour (or other Station).	
—— Words of not more than two Syllables at 4 annas ...	0 0 0
—— Additional Syllables ..	0 0 0
Boat hire	0 0 0
Reply —— Words of not more than two Syllables, at 4 annas	0 0 0
—— Additional Syllables ..	0 0 0
Peon hire......	0 0 0
Total charge,	
(Date and Name of Signaller)	

of any despatch on private business, but an entry will be made in the Station Journal in the form shown in the margin.

15.—All fees are to be paid in cash before the despatch of the message. All receipts on this account are to be carried to the credit of Government, and to be accounted for in Monthly Reports.

16.—Subscribers' privileges are obtained by Firms and individuals, on payment of a subscription of eight rupees a month.

17.—The Superintendent is vested with the power of appointing and removing all persons employed on the establishment. He may inflict fines for neglect of duty, but should such fines amount in any month to more than one-fourth of the salary or wages of the persons punished, the case shall be especially reported for the orders of Government.

ESTABLISHMENT.

The Establishment, pending further orders, shall consist of a Superintendent, Assistants and Workmen.

The Assistants are of four Classes.

First Class—Inspectors.

Qualifications.—A good English Education.

A correct knowledge of Orthography.

A perfect knowledge of the principles, construction, working, adjustment, protection and repairs of the lines of conductors, and of all the instruments employed.

Quickness and correctness in despatching and receiving Signals.

Knowledge of Marryatt's and Bedford's Marine and River Codes.

Good character for sobriety, diligence, and activity, and good habitual health.

Salary, 100 rupees (£10) a month, with 40 rupees for travelling expenses when employed out of Calcutta.

Second Class—Readers.

Qualifications.—A good English Education; correctness in Orthography; rapidity and precision in transmitting and reading Signals by Spelling, and with needle Telegraphs.

Knowledge of the adjustment of instruments, and of Marryatt's and Bedford's Codes.

Salary, 55 rupees (£5 10s.) to 75 rupees (£7 10s.) a month.

Third Class—Signallers.

Apprentices.

Qualifications.—A good English Education; correctness in transmitting Signals, and proficiency in reading Signals. Salary, 27-8-0 (£2 15s.) a month.

Fourth Class—Probationers.

Qualifications.—A good English Education. A Guarantee from a guardian, or parent, of readiness to enter into apprenticeship according to Act XIX. of 1850.

Probationers receive no pay, but are permitted to learn the practice of signalling at such stations as may be convenient, for a period of 3 months, when they will be subjected to examination, and discharged if not found qualified for admission on the Apprentice List. If employed at out-stations, or on temporary duty, they will receive pay at the rate of 16 rupees (£1 12s.) per month.

By order of the Hon'ble the Deputy Governor of Bengal,

J. P. GRANT,

Secretary to the Government of Bengal.

APPENDIX No. 4.

CONSTRUCTION OF COMPOUND POSTS WITH IRON SOCKET JOINTS.

It having been reported from India that much difficulty is experienced in procuring, at a moderate cost, a large supply of iron-wood spars of the length required, experiments have been instituted on the premises of Messrs. Ransome and Simms, at

Ipswich, to determine the best mode of constructing compound posts from smaller pieces of timber.

From these trials it is decisively proved that a perfect mode of accomplishing the object in view is afforded by the use of a cast iron double socket joining piece, prepared and adjusted as follows:—

The short spars available—say 10 feet long—are tapered at each end by a machine, constructed for the purpose by Messrs. Ransome and Simms, so that one end fits exactly in the screw pile (*see page* 38), while the upper end is inserted into the iron joining socket.

This is of cast iron, 2 feet long, $5\frac{1}{16}$ inches diameter, 28 pounds weight, of the best Staffordshire metal, annealed. The form is that of a double cone or slightly hour-glass shape, the thickness of the metal increasing towards the middle line. The lower post is covered 10 inches by this cap; and the upper post—say 8 to 10 feet long—is inserted into the upper and reversed cone as a socket.

In very numerous experiments with compound spars of this kind, a dynamometer being included in the breaking tackle, it was found that in every instance the straining power either broke the post close to the screw pile, or fractured the pile itself; but in no case was the iron socket injured or the upper spar broken. When the strain was made on the very top of the compound post, this bent like a fishing-rod in an even curve.

These sockets cost two shillings each, and an ample supply will be sent to India at once. By their use the abundant supply of short iron wood or teak can be made available, and bamboos employed with great advantage as the upper spars, thus reducing the cost of the compound post below that of timber in single pieces of equal length.

APPENDIX No. 5.

INJURIES TO THE CHAIN CABLE LINES ACROSS THE HULDEE AND HOOGHLY RIVERS.

Since the article at page 90 has been printed off, a demi-official report has been received of further injuries done to the

Huldee and Hooghly river lines, protected by chain cables. This system will accordingly be given up altogether, and cables, prepared with the parallel iron rods and rings, described at page 88, be substituted for chains the next time an interruption takes place.

APPENDIX No. 6.

SUCCESSFUL LAYING OF THE SUBMARINE TELEGRAPH CABLE BETWEEN DOVER AND OSTEND.

This important undertaking has just been completed with entire success. Through the extreme kindness of Sir James Carmichael, the writer has had the advantage of witnessing the whole operation, and is permitted to insert the annexed brief narrative of its successive stages.

The cable, manufactured by Messrs. Newall and Co. (*Fig.* 67, *page* 94), consists of six gutta-percha covered wires: five of No. 2 gauge, one of No. 4 ditto. These are served with a thick coating of hemp, spun-yarn, and tar, and enclosed in a spiral casing of twelve iron rods, ⅜-inch diameter, gauge No. 1, not galvanized, but well coated with Stockholm tar. The weight per mile is—

		Tons.	cwt.	qrs.	lbs.
Gutta-percha coated copper wire		0	9	3	21¾
Hemp, yarn, and tar		0	7	1	13
Iron rods, No. 1		5	18	0	25
Total per mile	Tons	6	15	2	4

The length of the cable is 70 statute miles. Total weight. 474 tons, 7 cwt. 2 qrs.

The cable was coiled, at Gateshead, on board the "William Hutt" iron screw steamer, all the lower decks, stanchions, fittings, &c., having been removed, so that the cable was arranged in three great coils, fore and aft. One end passing over a roller, was led to and over an iron saddle, erected on a frame about twelve feet high, attached to the mainmast; from this saddle it passed downwards to a cast-iron vertical drum, 7 feet 8 inches diameter, round which it took three turns, and then proceeded

over the ship's stern, between two vertical rollers placed sufficiently apart to allow of free lateral play to the cable as delivered.

To the drum was attached a lever and friction break, by which its rotation could be checked or totally stopped; also a set of measuring wheels, with a dial, to denote the length of cable expended as the operation advanced.

The turns of the cable in the ship's hold were separately lashed together laterally by spunyarn, and each tier also attached by similar lashings to the one below. The whole arrangement thus formed, as it were, a solid mass. Hand-ropes, firmly secured to the cross-beams at intervals of a few feet, enabled the men to hold on firmly with the left hand, while with the right each yarn lashing was cut in succession. The advantage of this prudent precaution was well proved in the rough weather which prevailed during a great part of the undertaking.

The "William Hutt" arrived off Dover on the 2nd of May. All being ready on the 3rd, the expedition started on the morning of the 4th, Captain Washington, R.N., on board the mail steamer "Vivid," being in charge of the nautical arrangements; Mr. Newall directing the paying out of the cable from the "Hutt," towed by the "Lord Warden" Dover steamer; H.M. reserve steamer "Lizard," Captain Ricketts, R.N., accompanying close alongside. At 4.45 a m. commenced landing the cable end for the cave at the South Foreland, with eight boats, the ship being about 1,000 feet off the shore. This was completed, and the end made fast ashore, at 6 a.m. The "William Hutt" started under her own steam, and towed by the "Lord Warden," at 6.20 a.m. At 8.10 a.m. thick fog set in; passed close to the South Sand floating light ship, and, further progress being impracticable, the ships anchored at 1.45 p.m., 31 miles of cable having been given out. The fog cleared off towards evening, and the squadron started again at 7.55 p.m., the "Vivid" with a light piloting ahead, and the "Lizard" burning blue-lights and rockets. At 2.30 a.m. anchored again in 14 fathoms, with a stiff breeze from N.E., and heavy, confused sea. The "William Hutt" now rolled violently, and her feed-pipes became so choked that her own steam was no longer available. Started again, in very rough weather, at 7.40 a.m. of the 5th of May.

The "Lizard" parted her chain cable and lost an anchor just as signal was made to weigh. At 9.40 the "Lizard" took the "William Hutt" in tow, and the "Lord Warden" cast off. At 10.20 the "Lizard's" towing hawser snapped, but the telegraph ship was secured almost instantly by the Dover tug. At [illegible]15 a.m., off Dunkirk, weather more boisterous. Anchored off Middlekirk, five miles west of Ostend, in half a gale, at 1.30 p m.

The paying out of the cable was thus effected at the rate of 4½ miles per hour. No accident occurred on board, and not a single "kink" or other casualty or derangement took place in the cable itself.

At 11.50 a.m. on the 6th of May, the remaining cable was removed from the "Hutt" on board a large Blankenburgh fishing smack, and attended by all the boats of the squadron. A warp rope was sent ashore and secured, and the smack, by underrunning the warp, hauled in through the heavy breakers, on the beach. All was finished at 1 p.m. exactly; the Belgian end of the cable carried in triumph to the Coast Guard House, on the Sand Hill, and, the wires having been connected, messages were sent through the cable to Dover, Calais, and London at 2 p.m.

The cable was then formally delivered over by Messrs. Newall and Co., amidst the congratulations and applause of all present, to Sir James Carmichael and Mr. Brett, directors, and Messrs. Crampton and Wollaston, the engineers of the Submarine Telegraph Company.

On the 7th of May, Mr. Wollaston proceeded, in the writer's presence, to test the insulation of the lines, and made numerous experiments of extreme interest on their telegraphic capabilities.

To test the lines, a delicate vertical galvanometer was employed (which, with one sand battery *couple*, gave a deviation of 35.00), and a sand and acid battery of 72 couples. With this —

Wire No. 1 gave deviation or loss of	1.50
2	1.50
3	1 50
4	1.50
5	1.50
6 (centre wire)	13

A single needle telegraph having been applied at each end to

each wire in succession, the needles were moved distinctly by the current from a single pair of plates; three pairs gave decided beats, and with 12 plates signalling was carried on with ease.

The wires were now joined, so that the current passed six times to and fro in one length of 70 + 6 = 420 miles. Through this great distance, all submarine, the signals passed strongly from 48 plates. The Calais submarine line was now added without impairing the result.

These experiments demonstrated the perfect practicability of telegraphing through a submarine cable 500 miles in length, and left no doubt on the minds of the observers of double that distance being as completely within the range of very moderate electric power.

To conclude, no operation on any scale could have been performed in a more masterly or thoroughly successful manner. We have only to add our warm wishes that the enterprising company to whom England and Europe are indebted for so great a benefit may reap a full measure of reward in the profitable working of the line thus auspiciously opened.

THE END.

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